RECORDS

OF THE

SURVEY OF INDIA

Volume IX

ANNUAL REPORTS OF PARTIES AND OFFICES

1914-15

From 1st October 1914
To 30th September 1915

SURVEY OF INDIA
1767
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PREPARED UNDER THE DIRECTION OF

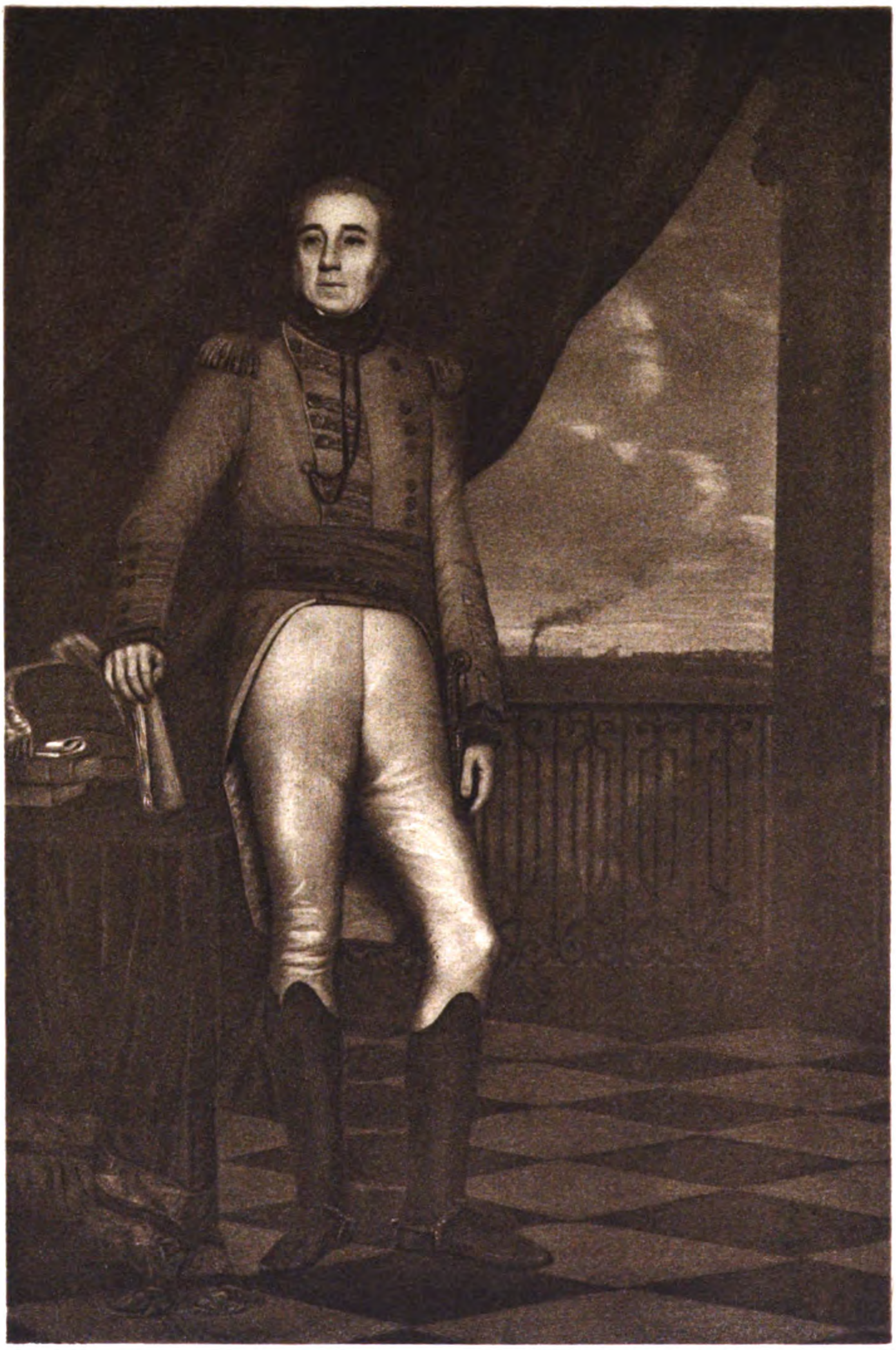
COLONEL SIR S. G. BURRARD, K.C.S.I., R.E., F.R.S.
Surveyor General of India

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1916

Price Four Rupees or Five Shillings and Four Pence

COLONEL COLIN MACKENZIE.

Surveyor-General of India, 1816–21.



Colin Mackenzie

FROM AN ORIGINAL OIL PAINTING IN THE TOWN HALL, CALCUTTA.

COLONEL COLIN MACKENZIE.

Madras Engineers.

Surveyor General in Madras	... ...	1809—1816.
Do. do. Calcutta	... ...	1816—1821.

Died in Calcutta on 8th May 1821, Aged 68.

The initiation of detailed Topographical Surveys based on Triangulation was due to Colonel Colin Mackenzie. In 1799 he commenced the Triangulation and Topographical Survey of Mysore. It was on this survey which was carried out mostly on the one-inch scale that the plane-table was first used in India.

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RECORDS OF
THE SURVEY OF INDIA.

PART I.—TOPOGRAPHICAL SURVEY.

NORTHERN CIRCLE.

(*Vide* Index Maps 1 and 4.)

Summary.—Four field parties worked in this Circle, and during the past field season a total area of 12,334 square miles was surveyed, consisting of:—

	Square miles.
Survey 1-inch	3,039
Re-survey 1-inch	4,826
Revision survey 1-inch	4,219
Survey ½-inch	250

The Riverain Detachment carried out a total of 1,299 linear miles of traversing over an area of 268 square miles for the Riverain work, 3,464 linear miles of traversing over 494 square miles for the Kāngra survey and 1,106 linear miles over 53 square miles for the Simla Settlement survey.

No. 20 Party surveyed an area of 19,578 acres in five selected cantonments during the year.

The Simla Survey Detachment continued the large scale survey of Simla during the year.

Colonel W. J. Bythell, R.E., was in charge of the Circle throughout the Survey year.

No. 1 PARTY.

BY MAJOR E. A. TANDY, R.E.

1. The winter programme of field work was cancelled and the office with the bulk of the party therefore remained in Mussoorie throughout the year. This enabled the arrears of fair mapping to be almost cleared off, while a programme of ½-inch mapping has been commenced to make up for the reduction in field work.

PERSONNEL.

Imperial Officers.

Lt.-Colonel C. H. D. Ryder, C.I.E., D.S.O., R.E., in charge from 27th January 1915.

Provincial Officers.

Mr. F. B. Powell, to 31st May 1915.
„ G. J. S. Rae, from 1st February 1915.
„ H. H. B. Hanby, in charge to 16th November 1914.
„ M. C. Petters, in charge to 26th January 1915.
„ P. A. T. Kenny.
„ D. K. Rennick, from 21st January 1915.
„ R. C. Hanson.
„ W. J. B. Miller, to 20th January 1915.
„ E. J. H. Hanby, from 7th May 1915.

Upper Subordinate Service.

Mr. Natha Singh, R.S.
„ Nanak Chand Puri, B.A., from 22nd May 1915.
„ Hamid Gul, from 1st March 1915.

Lower Subordinate Service.

33 Surveyors, etc.

2. *Field work* was confined to the maintenance of a single detachment working in the Himālayan areas of Kashmīr and Jammu to the west and north of Kishtwār, with extension of triangulation to the south.

3. *The summer detachment of 1914* consisting of Mr. Kenny with an average of 8 surveyors continued its work up to the end of December, when the following 1-inch sheets were completed :— $43\frac{K}{11, 12, 15, 16}$, $43\frac{O}{3, 4}$ and $52\frac{D}{1 (part)}$.

This detachment also revised some faulty work in the neighbouring sheets $43\frac{L}{1, 5, 9}$.

4. *The summer detachment of 1915* consisting of Mr. Hanson with an average of 9 surveyors, commenced in April the survey of the following sheets, the work being still in hand at the end of September, *viz.*:—$43\frac{N}{12, 16}$, $43\frac{O}{5, 7, 9, 10, 11, 13, 14, 15}$ and $52\frac{C}{3, 4, 7, 8}$.

This work was all on the 1-inch scale, excepting parts of $\frac{N}{12}$, $\frac{N}{16}$ and $\frac{O}{13}$, which lay amongst high snows and were surveyed on the ¼-inch scale in order to complete degree sheets to margin.

5. *Areas of survey* to the end of September were as follows :—

In 1914 . . . 623 square miles 1-inch.

„ 1915 . . . 1,572 „ „ and 250 square miles ¼-inch.

Total of new work 2,195 square miles 1-inch and 250 square miles ¼-inch.

6. *Triangulation in advance* was continued by Mr. Miller up to the end of December 1914, in sheets $43\frac{O}{5, 9, 10}$, $43\frac{P}{11, 15}$, the total area subsequent to the end of September 1914 being 1,350 square miles. This leaves the party with over 3,300 square miles of triangulation in advance after the completion of the sheets now under survey. All computations have been completed, but no fair charts have been drawn.

7. *Nature of country* included all varieties common to the southern face of the Western Himālayas from the plains and foot-hills up to snowy peaks exceeding 20,000 feet in altitude. Two fatal accidents occurred to *khalāsis* who were killed by falls in this difficult country; otherwise the general health has been very good.

8. *Office work.*—Owing to the practice in this party of keeping detachments working in the higher hills during the summer, in addition to doing a normal programme of field work in the cold weather, the work of fair mapping has been falling into arrears of late years. The recent reduction of field work has, however, now enabled arrears to be practically cleared off. Thirty-five fair maps of difficult country have been sent in for publication during the year, and the arrears still in hand consist of only seven sheets quite recently surveyed and all now approaching completion.

9. *A ½-inch mapping section,* under Mr. Rae, commenced fair mapping on the ⅜-inch scale at the beginning of April, using modern 1-inch published sheets as material. The following six sheets were taken up and are now approaching completion :—

All four sheets of 43 G, and the two southern sheets of 38 O.

10. *Cost-rates* have been affected by the abnormal nature of the year's programme, but work out as follows :—

	Rs.	
Triangulation	5·5	per square mile.
1-inch detail survey	16·2	ditto.
¼-inch do.	1·6	ditto.
Fair mapping 1¼-inch scale	3·5	ditto.

The total cost of the party was Rs. 90,052.

11. *Inspection.*—The party was inspected once by the Surveyor General and on several occasions by the Superintendent, Northern Circle.

No. 2 PARTY.

BY MR. B. R. HUGHES.

1. The field head-quarters of the party opened at Gurgaon on the 9th November 1914, and closed on the 27th March 1915, the recess quarters being at Mussoorie.

PERSONNEL.

Provincial Officers.

Mr. B. R. Hughes, in charge.
„ F. B. Powell, from 1st October 1914 to 31st January 1915, and re-transferred from 1st June 1915.
„ Kanak Singh.
„ R. E. Saubolle.
„ J. H. Johnson.
„ J. A. Calvert.

Upper Subordinate Service.

Mr. Chuni Lal Kapur, from 1st April 1915.
„ Lakshmi Dutt Joshi, from 1st January 1915.

Lower Subordinate Service.

27 Surveyors, etc., in the field.
13 „ „ employed on ½-inch mapping.
28 Average in recess (excluding absentees).

2. *Topography.*—The outturn of the party was :—

	Sq. miles.
1 inch=1 mile revision survey	2,550·3
1 „ =1 „ new survey	843·9
Total	3,394·2

In thirteen 1-inch sheets Nos. $44\frac{O}{4 \text{ and } 8}$, $53\frac{C}{16}$, $53\frac{D}{1, 2, 5, 6, 9, 10, 11, 13, 14, 15}$.

3. Surveyors were divided into two camps under Messrs. Saubolle and Johnson.

Traverser Inayat-ullah Khan's services were transferred to No. 14 Party (Pendulum) from the forenoon of the 19th April 1914, with a view to carrying on traversing for the survey of the Nepāl Boundary.

4. The survey was carried out from plotted trijunctions where old data were forthcoming, and from trees and other conspicuous objects laid down from new traversing, and triangulation.

In certain sheets where the plotted points happened to be based on different data, the position by survey of the same roads, etc., did not agree. This was due to the old revenue traverses not being sufficiently connected up with triangulated points which were then few and far between.

Values derived from connections with triangulated points brought up from Great Trigonometrical stations differed from the old revenue traverse values by nearly 3 chains in the southings and 1¼ chains in the eastings.

5. *Triangulation.*—Mr. Calvert triangulated an area of 1,200 square miles for future ½-inch detail survey in the Alwar State, in sheets $54\frac{A}{3, 6, 10, 14, \text{ portions of } 7 \text{ and } 11}$.

6. *Traversing.*—Ahmad Husain Khan ran 136 linear miles of height traverse in flat country where triangulation was not found possible, in sheets $44\frac{O}{4 \text{ and } 8}$ in the Bīkaner State, and also 148 linear miles in open country in sheets $53\frac{D}{12 \text{ (south half)}}$, $54\frac{E}{2 \text{ and } 6}$ in the Bharatpur State.

7. *Fair mapping.*—All the fair mapping of the 13 sheets surveyed during the field season will be completed and sent for publication before the party leaves for the field, and is being carried out under two drawing sections with one typing section.

The 1-inch plane-table sections, mostly surveyed in half sheets were blue-printed on the 1½-inch scale, one of the half sheets being blue-printed on drawing paper for direct drawing and the other half on tracing paper for transferring.

8. *Cost-rates*—

Revision survey, 1-inch	Rs.	9·84	per square mile.
New survey, 1-inch	„	10·20	„ „
Triangulation	„	3·41	„ „
Traversing	„	6·00	per linear mile.

9. *Health.*—This was good throughout, only two cases of *khalāsis* down with pneumonia, being sent to local hospital for medical treatment, both recovering.

10. *Inspections.*—The Superintendent, Northern Circle, inspected the party during the field season and also in recess.

The Surveyor General inspected the party in recess in September 1915.

No. 3 PARTY.

By Mr. H. H. B. Hanby.

PERSONNEL.

Imperial Officers.

Captain F. F. Hunter, I.A., in charge to 24th November 1914.
Captain F. B. Scott, I.A., to 26th October 1914.

Provincial Officers.

Mr. H. H. B. Hanby, from 17th November 1914, in charge from 25th November 1914.
„ E. J. Biggie.
„ E. B. West, from 1st November 1914 to 30th September 1915.
„ H. T. Hughes.
„ G. E. R. Cooper, from 1st November 1914.
„ Moqimuddin.

Upper Subordinate Service.

Mr. Mahomed Lutf Ali.
„ Muhammad Husain.

Lower Subordinate Service.

52 Surveyors, etc.

Training Section.

3 Pupils.

1. All the work lay in the United Provinces and embraced parts of the following districts, Bijnor, Sahāranpur, Dehra Dūn, Garhwāl, Muzaffarnagar, Meerut, Nainī Tāl, Bareilly, Pīlībhīt and Shāhjahānpur. With the exception of a little bit of the "Siwālik" hills in Sahāranpur and Dehra Dūn districts, and a portion of the Kumaun hills east of the Ganges river facing Hardwār, the country was flat, forest-clad areas were encountered along the foot hills also in the Taraī tahsīl of Nainī Tāl district, and in parts of Pīlībhīt.

The field season opened at Najībābād on 2nd November 1914 and closed on 6th April 1915.

2. *Topography.*—The total area surveyed on the 1 inch=1 mile scale was 3028·149 square miles, of which 1359·284 square miles were re-survey and 1668·865 square miles revision survey, the whole being contained in eleven and a half 1-inch sheets, *viz.* :—

$$53 \frac{K}{1, 2, 3, 6, 7, \text{ and northern half of } 11.}$$

$$53 \frac{P}{9, 10, 11, 13, 14, 15.}$$

In the above is not included $53 \frac{K}{11 \text{ southern half}}$; it was surveyed by the training section.

Three camps were formed and the following allotment of work was made :— Mr. G. E. R. Cooper $53 \frac{K}{1, 2, 3, 6, 7, \text{ and northern half of } 11}$, Mr. Moqimuddin $53 \frac{P}{9, 10, 13, 14}$, Mr. Mahomed Lutf Ali $53 \frac{P}{11, 15}$.

The average outturn per man per month for re-survey works out at 27·7 square miles and that for revision survey at 31·2 square miles.

The area revised was not carried out on blue prints of the original maps.

All trijunctions were plotted on fresh boards on to which the detail was transferred in blue, trijunctions being fitted over plotted trijunctions, and then checked in the field.

One would have thought that the progress of revising detail would have far exceeded that of re-survey, but owing to numerous changes since the last

survey, in rivers, extension of canal system, roads, railways, and new cultivation of lands at one time waste or forest-clad, the labour in the field was that of doing a new survey.

3. *Triangulation.*—Mr. E. B. West was employed on triangulation. The programme under this head embraced the following sheets :—53 $\frac{O}{2,\ 6,\ 7}$, for 4-inch survey, and 53 $\frac{K}{9,\ 13,\ 14}$, 53 $\frac{O}{1,\ 2,\ 5,\ 6,\ 9,\ 10,\ 13,\ 14}$, for 2-inch and $\frac{1}{2}$-inch survey, but with the intricate nature of the country, and the low convexity of the hills densely covered in trees with an absence of commanding peaks, he was only able to complete, before the monsoon broke, 830 square miles for future survey on scales 2 inches and $\frac{1}{2}$ inch to a mile in sheets 53 $\frac{J}{12 \text{ and } 16}$ portions only, 53 $\frac{K}{5,\ 9,\ 10,\ 13,\ 14}$ and 53 $\frac{O}{1,\ 2,\ 5,\ 6}$. 90 square miles were also triangulated for a special forest survey, on scale 4 inches = 1 mile, in sheets 53 $\frac{O}{2,\ 6,\ 7}$.

4. The health of the party during the season under report was fair in the winter months but bad in May and June when Taraī fever became prevalent.

5. *Traversing.*—At the request of the Conservator of Forests, United Provinces, Western Circle, a special theodolite traverse of 398 linear miles was run in the Rāmnagar Forest Division falling in sheets 53 $\frac{K}{14,\ 15}$ and 53 $\frac{O}{2,\ 3,\ 7}$. With the object of giving additional points, 335 linear miles were traversed for a future survey on the 1-inch scale, in sheets 53 $\frac{K}{15}$, and 53 $\frac{O}{3,\ 7}$.

107 linear miles were further traversed for a special forest survey on the scale of 4 inches = 1 mile in sheets 53 $\frac{O}{2,\ 6,\ 7}$.

The traverse camp was under Mr. E. J. Biggie till the 6th March 1915 when he was transferred temporarily to No. 4 Party.

6. *Recess duties.*—During the recess the party completed the mapping of the following sheets on the scale of $1\frac{1}{2}$ inches to 1 mile:—53 $\frac{K}{2,\ 3,\ 6,\ 11}$, 53 $\frac{P}{9,\ 10,\ 11,\ 13,\ 14,\ 15}$.

The remaining two sheets will be completed before the end of October 1915.

7. *Inspection visits.*—The party was inspected by the Superintendent, Northern Circle, in the field in February last, by the Surveyor General in recess in September, and visited on several occasions in recess by the Superintendent.

No. 4 PARTY.

BY MR. H. W. BIGGIE.

1. The field head-quarters of the party opened at Fyzābād on 19th October 1914, and closed on 12th April 1915, the recess head-quarters continued at Mussoorie.

PERSONNEL.

Imperial Officers.

Major L. C. Thuillier, I.A., in charge to 2nd November 1914.
Captain R. Foster, I.A., in charge from 3rd to 21st November 1914.

Provincial Officers.

Mr. H. W. Biggie, in charge from 22nd November 1914.
„ E. J. Biggie, from 8th March to 24th May 1915.
„ H. P. D. Morton, from 17th May 1915.
„ J. C. C. Lears.
„ Duni Chand Puri.

Upper Subordinate Service.

Mr. Mohammad Husain Khan.

Lower Subordinate Service.

47 Surveyors, etc.

The area that came under survey comprises portions of the districts of Bāra Bankī, Fyzābād, Sultānpur, Partābgarh, Jaunpur, Azamgarh and Bastī. It consists of flat plains which are highly cultivated and covered with orchards, mango trees being in great abundance. It is well-wooded but there is no forest, though shrub jungle occurs in many places. Village sites are numerous, and the area is densely populated. The principal rivers that run through portions of the area are the Gogrā and the Gumtī.

2. *Topography.*—The following sheets were fully surveyed :—63 $\frac{F}{14, 15, 16}$, 63 $\frac{J}{2, 3, 4, 6, 7, 8, 10, 11, 14, 16}$. Field work was divided into three camps under Messrs. J. C. C. Lears, Duni Chand Puri and Mohammad Husain Khan.

The average rate of plane-tabling (excluding the time taken in marching), was 33·48 square miles per man for a month of 30 days. The cost-rate of detail survey on the scale of 1 inch to 1 mile is Rs. 9·3 per square mile.

3. *Traversing.*—This consisted of supplementary traverses which were run wherever required, to provide points for detail survey.

4. *Triangulation.*—This was started by Mr. E. J. Biggie in 63 $\frac{E}{13}$, but owing to dust haze in April and May the work was not completed, and will be taken up again in field season 1915-16 to provide points for the detail survey of the Nepāl portion of the sheet.

5. *Miscellaneous field work.*—The Khetran-Leghari boundary between the Punjab and Baluchistān was demarcated by Captain R. Foster, I.A., at a cost of Rs. 1,316-11-3, which was paid for in equal shares by the two Governments concerned.

6. *Recess duties.*—The three camp officers mentioned in paragraph 2 above supervised the fair mapping which was divided into three sections. All fair maps of sheets surveyed during the field season will be completed and sent for publication about the end of October. Mr. Morton was employed on fair mapping and miscellaneous work.

Village boundary editions.—Twenty-three village boundary editions were prepared and sent for publication during the year.

7. *Health of the party.*—Four members of the party died during the year. Their names are Baldeo Prasad, Clerk, Narayan Datta, Atma Ram, and Bala Datta, Surveyors. Only one of these deaths, that of Atma Ram, was due to disease contracted in the field where the health of the party was good.

8. *Inspection visits.*—The Superintendent, Northern Circle, inspected the party during the field season in March, and visited the party during recess in May. The Surveyor General inspected the recess office of the party in September.

No. 20 PARTY—(CANTONMENT).

BY MR. A. EWING.

1. During the year under report, the party was employed on the survey of Meerut, Dehra-Dūn, Landour, Sahāranpur and Hāpur (Bābūgarh) Remount Depôts on the scale of 16 inches to a mile; and surveyed the bazaars of Meerut and Dehra Dūn on the scale of 64 inches to 1 mile. The triangulation and traversing of Peshāwar, Jullundur, Bannu, Kālka, Sanāwar and Bakloh have been completed in advance for season 1915-16. During the year Santa Cruz was re-traversed, a survey of the proposed pipe-line for New Delhi was done for the Military Works Department and the Guide Map of Mussoorie and Landour brought up to date. Twenty-one fair maps have already been sent for publication, eight fair maps will be sent for publication in a few days and fourteen sheets of Meerut have been drawn and examined.

PERSONNEL.

Provincial Officers.

Mr. A. Ewing, in charge.
" F. C. Saint, from 5th October 1914.

Upper Subordinate Service.

Mr. Dharmu.

Lower Subordinate Service.

5 Surveyors.
10 Draftsmen and Computers.
2 Clerks.
10 Pupils.

2. The field season commenced in Meerut on 1st October 1914 and closed in Dehra Dūn on 30th September 1915.

3. Owing to the party being employed on the survey of cantonments where sanitary arrangements are always good, there was not much sickness during the year. One khalasi died of pneumonia in Meerut. During the months of May and June cholera broke out among the troops in Dehra Dūn. The surveyors working there were promptly removed outside cantonment limits, and for two months very little work was done. This delayed the completion of the survey of Dehra Dūn for nearly two months.

4. *Topography.*—As Mr. F. C. Saint on his transfer to this party had no previous experience in the work of a cantonment party, Mr. A. Ewing took charge of the detail survey during the year; but was assisted in the testing of field sheets by Messrs. F. C. Saint and Dharmu. Both of them are now qualified to be placed in charge of sections and during next year they will be put in independent charge of six or seven surveyors employed on detail surveys.

The accuracy of detail surveys was thoroughly tested by Mr. A. Ewing by 24·18 linear miles of test lines in nearly every field sheet, and also by Messrs. F. C. Saint and Dharmu by 35·98 linear miles of partal in the five cantonments surveyed during the year.

The following table gives the outturn and costs of the survey of five cantonments surveyed during the year:—

Outturn.	*Cost Rs.*
19,260 acres on the 16-inch scale	20,579
318 do. do. 64-inch do.	3,662

The cost-rate of the 16-inch survey, *viz.*, Rs. 1·07 per acre, is less by Re. 0·23 than that of the last year's survey, but there is an increase of Rs. 2·63 in the cost-rate of the 64-inch survey which is Rs. 11·52 per acre. This increase is due to the Sadar Bazar of Meerut being very congested and intricate.

5. *Triangulation.*—Sufficient number of stations and intersected points were fixed in Sahāranpur Remount Depôt, Kālka, Landour and Santa Cruz for the connection of theodolite traversing. Messrs. F. C. Saint and Dharmu were employed on the triangulation done during the year. The triangulation of Bakloh will have to be done during next season, as the mark-stones found on the ground were not those fixed by the triangulator in season 1894-95. The triangulation done during the year was sufficiently accurate for the purpose for which it was done, *viz.*, fixing stations and points in and round the cantonments to connect the theodolite traversing and to check the chaining. 405 square miles of triangulation was done at a cost of Rs. 3,087-8-0.

6. *Traversing.*—During the year the traversing of Sahāranpur Remount Depôt, Hāpur (Bābūgarh) Remount Depôt, Bannu, Peshāwar, Kālka, Sanāwar, Jullundur and Landour Cantonments was completed. Santa Cruz was re-traversed to prepare a table of bearings and distances of the boundary pillars.

The traversing done by each member of the party is:—

Mr. F. C. Saint	195	stations	21·23	linear	miles.
Mr. Dharmu	276	do.	14·60	do.	do.
Gokul Chand	1,965	do.	264·31	do.	do.
Amir Ahmad	40	do.	1·63	do.	do.
Niaz Ahmad Khan	504	do.	19·48	do.	do.
Debi Datta	73	do.	8·48	do.	do.
	3,053	do.	329·73	do.	do.

The theodolite traversing both in angular work and chaining is very good. 30 azimuths, 3,053 angles and 330 linear miles were done at a cost of Rs. 11,481.

7. *Levelling.*—Some levelling was carried out in Meerut, Sahāranpur Remount Depôt and Hāpur (Bābūgarh) Remount Depôt. In Meerut, in addition to the four bench-marks of the Great Trigonometrical Survey, twenty-seven bench-marks were fixed by this party. No levelling was required in Dehra Dūn and Landour as there were enough Great Trigonometrical bench-marks in these cantonments. The levelling cost Rs. 862.

8. *Recess duties.*—Twenty-one fair maps have already been sent for publication, and eight more will be sent in a few days. Twenty-three sheets were drawn during the year. Ten sheets are in hand, and nine sheets of Dehra Dūn and Landour which were surveyed during the months of July, August and September are remaining to be drawn. These sheets will probably be completed in February 1916. The fair mapping was done under the supervision of Mr. A. Ewing, who examined all the sheets before sending them for publication. The cost of fair mapping for the year is Rs. 6,230. There is no arrear of fair mapping.

9. *Programme for season 1915-16.*—To be surveyed Peshāwar, Jullundur, Bannu, Kālka, Sanāwar, Bakloh, Simla lines, Upper Drosh, Lower Drosh, Fort Lockhart, Hangu, Thal and Chitrāl. To be triangulated and traversed in advance for season 1916-17, Rāwalpindi, Jhelum, Siālkot, Upper and Lower Topa, Chaman and Nīmach.

RIVERAIN DETACHMENT.

BY MR. MAYA DAS PURI, RAI SAHIB.

PERSONNEL.

Provincial Officer.

Mr. Maya Das Puri, Rai Sahib, in charge.

Upper Subordinate Service.

Mr. Paras Ram, from the 10th December 1914.

Mr. Vidya Dhor Chopra, from the 1st November 1914.

Lower Subordinate Service.

83 Surveyors, etc.

1. The field operations opened on the 1st October 1914, and closed early in August 1915. Three traversers in Kāngra and one in Simla, were, however, continuously employed during August and September 1915 for completing the work urgently required by the Settlement authorities.

The office was moved down from Dharmsāla to Gujrāt on the 15th October 1914. During January plague broke out at Gujrāt and so it was again shifted on the 8th February 1915 from there to Campbellpur which was made the permanent head-quarters of the detachment from the 1st July 1915 on account of its being a healthy station.

During the year Mr. Paras Ram, Sub-Assistant Superintendent, supervised one of the Kāngra field sections and plotting.

Mr. Vidya Dhor Chopra, Probationer (Upper Subordinate Service) was employed on traversing Simla proper and on computations.

Munshi Ganda Singh *Naib Tahsildar* looked after the riverain, and the Simla (Bharauli and Kot Khai tracts) traversing, and a computing section.

Babu Ishwar Singh, Surveyor, continued to supervise the Kāngra field work, and in addition got the Kāngra trunk road surveyed for the Executive Engineer, Provincial Division, Kāngra.

The detachment continued the work of traversing and laying out base lines. Twenty-one linear, and 37 square miles of main circuits, and 1,278 linear, and 231 square miles of minor traverse were run, and 5,387 theodolite stations fixed in the area under water action of the rivers Sutlej, Rāvi, and Chenāb in districts Jullundur, Siālkot, and Gujrāt. One hundred and fifty-nine corners of 53 rectangles were demarcated in 174 square miles with permanent mark-stones on the banks of the Chenāb (districts Gujrāt and Gujrānwāla) to serve as bases for the future survey and demarcation of boundaries in the bed of the river. Nine corners of 3 squares were re-demarcated at the special request of the Settlement Officer in a small portion of the Rāvi, 2½ miles long, in district Siālkot. One thousand two hundred and forty-eight plotted and 348 boundary "*māsāvis*" (Settlement mapping sheets) of 140 villages were completed, on the scale 40 *karms*, local unit of measurement varying in different districts, and twenty-two 4-inch sheets, and twelve 1-inch indexes were traced, and supplied in time to the Settlement Officers of Jullundur, Siālkot, and Gujrāt. Besides these 61 miscellaneous traces were prepared, and all the traverse stations marked during the year were plotted on twenty-one 4-inch sheets. Four 4-inch riverain boundary sheets were compiled, 9 sheets typed, and 3 sheets finally completed.

The following tables give full details of the riverain work completed during the year:—

(1).—*Field work.*

Names of the rivers, districts and the scales.	Straight length in miles.	MAIN CIRCUIT.			MINOR TRAVERSE FOR DETAIL SURVEY.				BASE LINES.			REMARKS.
		No. of square miles.	Linear miles.	No. of theodolite stations.	No. of square miles.	Linear miles.	No. of theodolite stations.	No. of villages.	No. of corners.	No. of squares or rectangles.	Area in square miles.	
SUTLEJ RIVER.												
Jullundur . . . Scale 165 feet = 1 inch.	56	..	...	...	103	502	2,080	79	...	...	...	
RĀVI RIVER.												
Amritsar and Siālkot .	2·50	...	...	...	...	21	47	...	9	3	...	Re-demarcated.
CHENĀB.												
Gujrāt and Gujrānwāla . Scale 220 feet = 1 inch.	64	37	21	32	128	755	3,228	61	159	53	174	
TOTAL .	122·50	37	21	32	231	1,278	5,355	140	168	56	174	

(2).—*Office work done for the cadastral surveys of Riverain estates.*

Name of river.	Name of district.	Scale of *masavis*.	Number of plotted *masavis* showing traversed points.	Number of compiled *masavis* showing riverain boundaries.	Number of sheets traced for the use of Settlement Officers on scale 4 inches = one mile.	Number of 4-inch sheets on which new work was plotted.
Sutlej . . .	Jullundur . .	165 feet = 1 inch.	633	183	8	8
Rāvi . . .	Siālkot . . .	...	...	...	1	...
Chenāb . . .	Gujrāt and Gujrānwāla.	220 feet = 1 inch.	615	165	13	13
		Total .	1,248	348	22	21

Besides these twelve 1-inch indexes, and 61 miscellaneous traces were prepared during the year.

(3).—*Office work done for the 4-inch compilation of riverain boundaries.*

Names of rivers.	Names of the series.	Number of sheets compiled.	Number of sheets typed.	Number of sheets finally examined and completed.
Chenāb	Gujrāt / Gujrānwāla	1	3	3
Chenāb	Shāhpur / Gujrānwāla	3	5	...
Jhelum	Jhelum / Gujrāt	...	1	...
	TOTAL .	4	9	3

2. The *Kāngra special survey* was started at the end of October 1914 in the *Kāngra tahsil* in continuation of last year's programme under similar conditions as existed during the previous season. The *Nūrpur tahsil* was taken up early in February 1915, and the work was divided into two camps, *i.e.*, *Nūrpur* under Mr. Paras Ram, Sub-Assistant Superintendent, and *Kāngra* under Babu Ishwar Singh, Surveyor, but during April 1915 Mr. Paras Ram came to office owing to ill-health, and hence the two camps were again combined in May 1915. The field strength working out was reduced to one-half during April 1915 and the men thus relieved were either sent on departmental leave, or employed in office at the head-quarters. The scale of the survey was generally 20 and 40 *karms* to an inch except in a few villages which were plotted on the scale 80 *karms* to an inch. The length of the *karm* is 57·5 inches.

In order to reduce the cost no boundaries were enlarged from the topographical maps in the snowy portions and tracts covered with forest reserves except 2 miles of disputed State boundary falling in 3 "*māsāvis*" between the Chamba State and Nūrpur *tahsil*; but they were, however, independently surveyed by the *patwāris*.

The cost works out to Rs. 118·6 per square mile. Rs. 5·1 are due to the grain compensation having been paid to the subordinates and menials during the current season. After deducting this item it comes to Rs. 113·5 as compared with Rs. 117·3 of that of the last year.

Three thousand four hundred and sixty-four linear, and 494 square miles were traversed and triangulated. 19,824 stations were fixed with theodolite in 1,011 *tikās* (sub-villages), and 4,834 plotted and 3 boundary *māsāvis* of 1,050 *tikās* completed during the year.

3. Under orders of the Punjab Government, the Simla Settlement Survey was started early in November 1914 in the Bharauli tract of the Simla district. During January 1915 the Simla-proper was commenced where in addition to the ordinary work 272 stations (239 boundary pillars and 33 stones) with heights, were picked up for the Simla detachment. After completing the Simla *tahsil*, the Kot-Khai *tahsil* was taken up during May 1915. As the work here was urgently required by the Settlement authorities it was continued during the whole of summer. The ground here was more difficult than that of Kāngra and so most of the stations were thrown by triangulation. The

average number of points laid out here works out to 57 per square mile, *i.e.*, 43 per cent. more than what were fixed in Kāngra. The work was based on the triangulation of the old No. 18 Party (Himālayas). The scale of survey was 20 and 40 *karms* to an inch. One *karm* =54 inches. In all 1,106 linear and 53 square miles were traversed and triangulated, 2,989 stations fixed with theodolite in 174 villages, and 364 plotted and 13 boundary *māsāvis* of 136 villages completed.

4. With a view to prepare a correct map on the same basis as that of the Kāngra Settlement and thus to avoid future boundary disputes, the *survey of the Kāngra trunk road* was undertaken during February 1915 at the request of the Executive Engineer, Provincial Division, Kāngra. Off-sets were taken on traverse lines to various boundary turnings and pillars and after applying the necessary corrections to distances measured along the road, for elevation or depression, the results were plotted on the scale 200 feet to an inch. Portions of the road facing 16 important bazaars were plotted on the scale 50 feet to an inch. The plots were then tested on the ground in various places by the camp officer. Theodolite stations traversed for the Settlement Survey were generally utilized and in addition 418 fresh points covering 34 linear miles were laid out. In all 39 miles of the road were surveyed and completed, *i.e.*, 36·1 miles from mile No. 48·7 to No. 84·8 and 2·5 miles from mile No. 89 to No. 91·5. 44 sheets (size of a sheet =20 inches ×28 inches) were plotted and completed on the scale 200 feet to an inch, and 19 sheets on the scale 50 feet to an inch; and a trace of 2·5 miles was supplied to the Executive Engineer, Provincial Division, Kāngra. Traces of the remaining area are in hand and are expected to be finished by November 1915.

5. As required by the Deputy Commissioner, Lahore, a small area of 719 acres was traversed and surveyed on the scale 12 inches to a mile to check the boundaries of grass land in the *Lahore Cantonment* given on lease by the Cantonment authorities. The traverse containing 33 stations and 7 linear miles was computed by using the magnetic bearing as it was not considered necessary, for economical reasons, to connect it with any traverse or trigonometrical station. The trace of the map showing discrepancies in area, etc., as compared with the plan already prepared by a military surveyor was supplied to the Cantonment Magistrate, Lahore.

6. Thirty-two stations covering 29 linear miles were re-demarcated in the Khushāb *Thal* (sandy area) as asked by the Settlement Officer, Shāhpur; and the cost debited to the Settlement Officer who recovered it from the *zemindārs* concerned.

7. The riverain area in the beds of rivers was, in general, full of shrubs, and in parts cultivated. Portions above the high banks were open, flat, and well wooded.

The Kāngra portion varied from open low-lying tracts in the Kāngra Valley to the high ranges of Nalru, Drun, Bhingsutri, Lakka, and Mauhali *Dhārs* (spurs).

In Simla the ground consisted of high mountains from 3,500 to 9,500 feet high, mostly cultivated and partly covered with forest reserves.

8. The *health of the detachment* was good on the whole chiefly due to the change of head-quarters, although cholera was raging in the Kāngra Valley and plague in the riverain area. Two *khalāsis*, however, died at their homes while on departmental leave.

9. The Kāngra and the Simla surveys were connected with Hātīdhār H. S. XXII, Lipīānā H. S. XXI, Sidpur H. Tower, Tirloknāth No. 1 H. S., Dhār H. Staff, Jamaurā H. Staff, Rihlū Fort, Sikot H. Staff, Yol H. Staff, Sukho H. S., Jasaur H. S., Rangaurtīlā H. Staff, Mānītīlā H. S., Koprā H. S., Marūrī H. S., and 69 stations of the old No. 18 Party (Himālayas), and the riverain work with Hazāra T. S. XXXIX.

10. The average errors in the three main classes of work were as follows :—

1. Riverain Survey—

(a) Base lines 1·12 feet per corner when compared with the theoretical values.

	Angular error per station in seconds.	Linear error in links per ten chains.
(b) Main circuits	5·19	0·70
(c) Minor traverse	8·18	1·10
2. Kāngra traversing and triangulation	8·27	1·77
3. Simla traversing and triangulation—		
(a) Simla proper	3·52	0·49
(b) Bharauli and Kot-Khai tracts	3·66	1·10

11. The total expenditure of the detachment from the 1st October 1914 to 30th September 1915 was Rs. 91,189 as detailed below :—

	Rs.
1. The Riverain Survey	22,865
2. The Kāngra Settlement Survey	58,610
3. The Simla Survey	8,992
4. The Kāngra Road Survey	585
5. The Lahore Cantonment Survey	50
6. The Khushāb *Thal* Re-demarcation	87

12. The detachment was inspected by the Surveyor General on the 15th November 1914; by the Superintendent, Northern Circle, on the 17th December 1914; and by the 1st Financial Commissioner, Punjab, on the 22nd March 1915.

SIMLA SURVEY DETACHMENT.

BY MR. C. E. C. FRENCH.

1. The head-quarters of this detachment remained in Simla during the season and continued the large scale survey of the station, including the work detailed in paragraph 3.

2. The area worked over embraces the town of Simla and the neighbourhood, hills ranging to 8,000 feet, covered in parts with heavy forest.

PERSONNEL.

Provincial Officers.

Mr. C. E. C. French, in charge.
" W. H. Strong, from 1st January to 7th August 1915.
" O. D. Jackson, from 29th March 1915.

Upper Subordinate Service.

Mr. Chuni Lal Kapur, from 17th December 1914 to 1st April 1915.
" Paras Ram, to 9th December 1914.
" Imam Din, promoted from the Lower Subordinate Service from 1st July 1915.

Lower Subordinate Service.

14 Surveyors, etc., of whom 7 returned to their parties on the 1st April 1915.

FIELD WORK.

3. The following work was done by this detachment :—

(*a*) *Topography.*—With accurate contouring of 2,700 acres in Simla, on a scale of 125 feet to 1 inch, completed by an average number of 8 surveyors.

(*b*) Large scale plans of 8 Bazaar blocks in Simla.

(*c*) Forest areas in Koti State; 8 square miles on a scale of 4 inches to 1 mile of actual forest land (with estates and villages inside forests, and overlap adjoining the boundary, or between adjacent forest blocks, an area of 14 square miles of country has been surveyed and mapped.)

(*d*) *Simla Extension Area.*—Hitherto a little over 1 square mile of country lying in Patiāla State has been surveyed. The exterior limits are theodolite traversed, with accurate contours at 20-feet intervals. Building sites and forest classification are marked in the Tāl block.

(*e*) *Sanjauli-Spur Survey.*—This plan was requisitioned by the Education Department to illustrate a proposed Indian College Scheme. Six surveyors of the detachment were employed on this for a fortnight. The area surveyed embraces 1·3 square miles of country, with contours at 50-feet intervals.

(*f*) Under this heading are grouped a number of miscellaneous pieces of work, some of which are mentioned below :—

(*i*) Several plans and tracings from the Simla field sheets (with areas of some 81 acres) to accompany a proposed colonisation scheme, a building restriction area, and three road alignments.

(*ii*) A series of spirit levelled heights for proposed electric lifts, with two plans.

(*iii*) A trace of the Viceregal Estates in Simla, including a survey and plan of the Retreat in Mashobra, also similar maps of the Catchment Area, Nābha House Estate, and areas of proposed Bazaar improvement (the last with sectional drawings).

Aggregate cost Rs. 4,300.

4. The cost-rate form (Table III) not being suitable for work of this varied description on different scales, it has not been completed, the total area and the total cost only being given.

5. *Office work.*—Ten fair sheets of the Simla survey are well advanced. The Koti State Forest map has been despatched. A tracing of the Sanjauli Spur survey with 6 ferrotype prints has been supplied and the fair map will be ready in a few days. Other information noted in paragraph 3(*f*) has been issued to the officers concerned.

6. The triangulation, traversing and mapping done by the detachment were relatively small, of a fragmentary nature and undertaken to meet special requirements; the expenditure for them has therefore been included under topography.

7. The detachment has now the following work left to do :—

(*a*) Completion of 1,200 acres of the Simla survey.

(b) A proposed plan of 5·3 square miles of country on a scale of 8 inches to 1 mile, illustrating a boundary dispute between Patiāla and Koti States.

(c) Drawing of the remaining 21 sheets of the Simla maps.

It is estimated that these works will be completed by March 1916.

8. *Inspections.*—The Surveyor General inspected the detachment on the 15th June; the Superintendent of the Circle on the 31st March, Colonel Ryder on the 14th July and Major E. A. Tandy from the 27th September to the 1st October 1915.

SOUTHERN CIRCLE.

(*Vide* Index Maps 2 and 5).

Summary.—This Circle was under the superintendence of Colonel T. F. B. Renny-Tailyour, C.S.I., R.E. throughout the year and consisted of Nos. 5, 6, 7 and 8 Parties, No. 4 Drawing Office and a Training Section.

During the year 19,286 square miles of detail survey, 14,516 square miles of triangulation and 186 linear miles of theodolite traversing have been completed.

The detail survey consists of :—

5,096	square	miles	of	½-inch survey.
9,532	„	„	„	1-inch survey.
3,547	„	„	„	1-inch revision survey.
134	„	„	„	1-inch supplementary survey.
508	„	„	„	1½-inch survey.
469	„	„	„	2-inch survey.

In spite of the reduction in the number of the supervising officers on account of the war, the full programme of detail survey, which is a record yearly outturn for the Circle, has been practically completed, but, on the other hand, very little more than two-thirds of the programme of triangulation has been completed.

The following work was undertaken in the Photo-Zinco Section of No. 4 Drawing Office :—

Reproductions	117
Enlargements	137
Reductions	209
Sheets vandyked	93
Copies printed	5,280

No. 5 PARTY (CENTRAL PROVINCES AND BERĀR)

BY MR. J. O'B. DONAGHEY.

This party completed the detail survey on the 1-inch scale of sheets 55 $\frac{G}{1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16}$, 55 $\frac{K}{1, 2, 3}$ and on the 2-inch scale of a small area of re-sevred forest in 55 $\frac{G}{4}$. The party also completed the triangulation of sheets 55 $\frac{C}{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16}$ and carried out theodolite traversing in sheets 55 $\frac{C}{12, 16}$.

The general nature of the country consists of forest-clad hills, undulating open uplands and highly cultivated plains.

The field season opened on the 23rd October 1914 and closed on the 30th April 1915. The field head-quarters was at Betūl.

PERSONNEL.

Imperial Officers.

Captain E. C. Baker, R.E., in charge to 21st October 1914.
Lieutenant R. S. Wahab, I.A., to 21st October 1914 and in charge from 22nd October to 28th November 1914.

Provincial Officers.

Mr. J. O'B. Donaghey, to 28th November 1914 and in charge from 29th November 1914.
„ F. C. Pilcher.
„ Munshi Lal, B.A.
„ C. O. Picard.
„ A. V. Dickson, to 8th July 1915.

Upper Subordinate Service.

Mr. Eknath Battu.
„ Damodar Kadilkur, from 14th October 1914.

Lower Subordinate Service.

32 Surveyors, etc.

The *health of the party* during the first three months of the field season was indifferent, malarial fever being prevalent in the country along the Tāpti

river. One *khalāsi* died during the field season and, owing to bad health, Mr. Dickson had to proceed on three months' leave.

Topography.—The 1-inch survey portion of the country varies from some intricate hilly ground along the Tāpti river to the open undulating uplands of the Sātpurā plateau and the highly cultivated plains of Berār. The 1-inch revision survey and the 2-inch survey portions consist entirely of forest-clad hills of the Sātpurā and Gāwīlgarh ranges. The elevation of the country surveyed varies from under 1,000 feet in the Berār plains to 3,864 feet, the highest point of the Gāwīlgarh hills; the average elevation of the Sātpurā plateau portion is over 2,200 feet.

The work was distributed as follows :—

No. 1 Camp.—Under Messrs. Donaghey and Damodar Kadilkur with 8 surveyors carried out the detail survey on the 1-inch scale in sheets $55\frac{G}{13}$, $55\frac{K}{1, 2}$.

No. 2 Camp.—Under Mr. Pilcher with 8 surveyors carried out detail survey on the 1-inch scale in sheets $55\frac{G}{1, 5, 6, 9, 10, 14, 15}$.

No. 3 Camp.—Under Mr. Munshi Lal with 11 surveyors carried out detail survey on the 1-inch scale in sheets $55\frac{G}{7, 8, 11, 12, 16}$, $55\frac{K}{3}$ and surveyed on the 2-inch scale a small area of reserved forest in sheet $55\frac{G}{4}$.

No difficulty was met with in the 1-inch survey, the country being fairly open throughout and interpolation easily obtainable. The area of the 1-inch revision survey was comprised of reserved forests, previously surveyed on the 4-inch scale ; after reduction by photography of the 4-inch published maps to the 1-inch scale, vandyked prints in blue were obtained of the reduced work on Bristol boards, on which the revision work was carried out in the field. The old 4-inch work was found to be of a reliable quality.

The full programme of the party amounting to 4,435 square miles was completed. The outturn of the 1-inch survey, of the 1-inch revision survey and of the 2-inch survey was 3,070, 1,357 and 8 square miles respectively, the average monthly outturn per man was 30·2, 58·7 and 7·6 square miles respectively and the cost-rate per square mile was Rs. 11·1, Rs. 7·0 and Rs. 25·9 respectively.

Triangulation.—The nature of the country is hilly, interspersed with open undulating areas.

Mr. Picard completed an area of 2,217 square miles in sheets $55\frac{C}{1, 2, 3, 4, 7, 8, 12, 16}$. Mr. Dickson, who was absent on sick leave for three months during the field season, completed an area of 829 square miles in sheets $55\frac{C}{5, 6, 9}$ and Mr. Eknath Battu, who was also employed on traversing, completed an area of 460 square miles in sheets $55\frac{C}{10, 14}$.

The total outturn was 3,506 square miles and the cost-rate per square mile was Rs. 6·1.

Traversing.—The nature of the country is flat.

Mr. Eknath Battu, during part of the field season, completed 42 linear miles in sheets $55\frac{C}{12, 16}$.

Connections were made with trigonometrical stations and 7 azimuths were observed.

The cost-rate per linear mile was Rs. 24·2.

Recess duties.—The fair mapping was divided between two sections as follows :—

No. 1 Section.—Under Mr. Pilcher, sheets 55 $\frac{G}{1, 5, 6, 9, 10, 14}$, 55 $\frac{K}{1, 2}$.

No. 2 Section.—Under Mr. Munshi Lal, sheets 55 $\frac{G}{7, 8, 11, 12, 13, 15, 16}$, 55 $\frac{K}{3}$.

The fair mapping of these sheets should be completed by the end of 1915.

The total area of fair mapping was 4,427 square miles and the cost-rate per square mile was Rs. 3·0.

The computations of the triangulation, under the supervision of Mr. Picard, were not completed on account of the reduction in the number of officers due to the war.

Triangulation charts 54 L, 55 N are in hand.

Miscellaneous.—The following information will be found useful when the survey of the country, dealt with in this report, is being revised :—The correct delineation on the 1-inch scale, of undulating or more or less flat country, by contours at vertical intervals of 50 feet and by the judicious use of form lines, requires a considerable amount of skill; and in this respect a 1-inch topographical map under revision could always be improved on by the employment of suitable men in the field work. It would thus be advisable to employ a surveyor with a "good eye for country" in the revision of sheets 55 $\frac{G}{8, 10, 11, 12, 13, 14, 15, 16}$, 55 $\frac{K}{1, 2, 3}$.

The country along the Tāpti river and in the Melghāt tāluk of the Amraotī district is notoriously malarious during the months of October, November and December; it would, therefore, be advisable not to undertake field work in sheets 55 $\frac{G}{1, 5, 6, 7, 9, 10, 11, 14}$ before the 1st January.

Camel transport will be found most convenient for triangulators and camp officers, plane-tablers can always obtain carts.

No. 6 PARTY (BERĀR, BOMBAY AND HYDERĀBĀD).

By MAJOR L. C. THUILLIER, I.A.

This party completed the detail survey on the 1-inch scale of sheets 55 $\frac{D}{1 \text{ to } 8}$ and on the $\frac{1}{2}$-inch scale of sheets 47 $\frac{M}{N.W., N.E., S.E.}$, 56 $\frac{A}{N.W., S.W.}$, except that small areas of reserved forests in sheets 55 $\frac{D}{1, 3, 4, 5}$, 56 $\frac{A}{1}$ were surveyed on the 2-inch scale and the areas of Bombay and Berār in sheets 47 $\frac{M}{N.W., N.E., S.E.}$, 56 $\frac{A}{N.W.}$ were surveyed on the 1-inch scale. The party also undertook the triangulation for the $\frac{1}{2}$-inch scale of sheets 56 $\frac{B}{3, 4, 7, 8, 10, 11, 12, 14, 15, 16}$, 56 $\frac{F}{1 \text{ to } 16}$.

PERSONNEL.

Imperial Officers.

Lieutenant-Colonel F. W. Pirrie, I.A., in charge from 22nd October to 8th December 1914.
Major L. C. Thuillier, I.A., in charge from 9th December 1914.
Captain K. W. Pye, R.E., in charge to 21st October 1914.

Provincial Officers.

Mr. P. R. Anderson, from 14th June 1915.
" E. A. Meyer.
" Haji Abdul Rahim, K.B.
" F. B. Kitchen.
" R. B. Gildea, to 25th May 1915.
" J. C. St. C. Pollett, from 1st July 1915.
" K. S. Gopalachari, B.A.
" J. O'C. Fitzpatrick, to 10th June 1915.

Upper Subordinate Service.

Mr. Ram Narayan Hastir.

Lower Subordinate Service.

33 Surveyors, etc.

The general nature of the country is varied, consisting to the north of intricate hills and to the south of broad undulating valleys and cultivated lands broken by rocky ridges with occasional high and rocky flat topped hills.

The field season opened on the 23rd October 1914 and closed on the 17th April 1915. The field head-quarters was at Aurangābād.

The health of the party was good.

Topography.—The nature of the country surveyed is varied ; open plains, undulating country and intricate hills for the ½-inch survey, intricate hills and rough country for the 1-inch survey, open plains and undulating hills for the 1-inch revision survey and intricate ground with thin forests for the 2-inch survey.

The work was divided among four camps as follows :—

No. 1 Camp.—Under Mr. Meyer with 5 surveyors carried out detail survey in sheets $47\frac{\text{M}}{\text{N.W., N.E.}}$.

No. 2 Camp.—Under Mr. Kitchen with Mr. Gopalachari and 11 surveyors completed the detail survey in sheets $55\frac{\text{D}}{1, 2, 3, 5, 6, 7}$.

No. 3 Camp.—Under Mr. Gildea with 8 surveyors completed the detail survey in sheets $55\frac{\text{D}}{4, 8}$, $56\frac{\text{A}}{\text{N.W.}}$.

No. 4 Camp.—Under Mr. Fitzpatrick with 3 surveyors carried out the detail survey in sheets $47\frac{\text{M}}{\text{S.E.}}$, $56\frac{\text{A}}{\text{S.W.}}$.

The full programme of the party, amounting to 7,640 square miles, was completed. The contour interval for the ½-inch scale was altered from 50 feet to 100 feet during the field season, this would probably tend to improve the outturn, but since cultivation and jungle limits with the exception of small unimportant areas are now being put in, the changes will more or less balance each other.

The outturn of the ½-inch survey, of the 1-inch survey, of the 1-inch revision survey and of the 2-inch survey was 5,096, 2,261, 261 and 22 square miles, respectively, the average monthly outturn per man was 80·1, 26·6, 29·0 and 5·6 square miles respectively and the cost-rate per square mile was Rs. 5·3, Rs. 10·6, Rs. 9·7 and Rs. 20·0 respectively. Areas of 5,096 and 298 square miles of ½-inch and 1-inch survey respectively were in Hyderābād. The figures for the 2-inch scale include plane-table surveys on the 4-inch scale of reserved forest boundaries ; 4 of the 22 square miles, given as the area surveyed on the 2-inch scale, were actually surveyed on the 4-inch scale, the boundary and the detail survey being combined, this action was economical owing to the intricate nature of the boundary.

Triangulation.—The nature of the country triangulated is low broken hills and undulating valleys.

Mr. Haji Abdul Rahim completed an area of 5,077 square miles in sheets $56\frac{\text{B}}{15, 16}$, $56\frac{\text{F}}{1 \text{ to } 16}$, and Mr. Ram Narayan Hastir completed an area of 2,258 square miles in sheets $56\frac{\text{B}}{3, 4, 7, 8, 10, 11, 12, 14}$. The triangulation was carried out for the ½-inch scale.

The total outturn was 7,335 square miles and the cost-rate per square mile was Rs. 3·1. An area of 7,277 square miles was in Hyderābād.

Recess duties.—The fair mapping was divided among four sections as follows :—

No. 1 Section.—Under Mr. Anderson, ½-inch sheets $47\frac{\text{M}}{\text{S.E.}}$, $56\frac{\text{A}}{\text{S.W.}}$ and 1-inch sheets $47\frac{\text{M}}{11, 12}$.

No. 2 Section.—Under Mr. Meyer, ½-inch sheets $47\frac{\text{M}}{\text{N.W., N.E.}}$ and 1-inch sheets $47\frac{\text{M}}{1, 2, 6, 13}$.

No. 3 Section.—Under Mr. Kitchen, 1-inch sheets $55\frac{\text{D}}{1, 2, 3, 5, 6, 7}$.

No. 4 Section.—Under Mr. Pollett, ½-inch sheet $56\frac{\text{A}}{\text{N.W.}}$ and 1-inch sheets $55\frac{\text{D}}{4, 8}$, $56\frac{\text{A}}{1, 5}$.

All the sheets were completed to margin with the exception of the 1-inch sheets $47\frac{M}{1, 2, 6, 11, 12, 13}$, $56\frac{A}{1, 5}$ which only contain the areas of Bombay or Berār falling in them. No. 4 Drawing Office lent some draftsmen to assist the work and all the fair mapping should be completed by the end of the recess season.

The total area of fair mapping was 8,220 square miles (5,605 square miles for the ½-inch scale and 2,615 square miles for the 1-inch scale) and the cost-rate per square mile was Rs. 2·3. Areas of 5,219 and 175 square miles of fair mapping for the ½-inch and 1-inch scales respectively were in Hyderābād. An area of 386 square miles in Bombay and Berār was fair-mapped for both the ½-inch and 1-inch scales.

The computations of the triangulation were completed under the supervision of Mr. Haji Abdul Rahim.

Triangulation charts 55 D, 56 E were practically completed and charts 47 M, 56 A are in hand.

No. 7 PARTY (MADRAS, MYSORE AND PONDICHERRY).

BY MR. W. M. GORMAN.

PERSONNEL.

Imperial Officers.

Lieutenant-Colonel F. W. Pirrie, I.A., in charge to 21st October 1914.

Captain J. D. Campbell, R.E., to 21st October 1914.

Provincial Officers.

Mr. W. M. Gorman, to 21st October 1914 and in charge from 22nd October 1914.
" C. S. Littlewood, to 16th August 1915.
" V. W. Morton, from 1st July 1915.
" C. West.
" H. H. P. Butterfield.
" J. C. St. C. Pollett, to 30th June 1915.
" N. S. Harihara Iyer.

Upper Subordinate Service.

Mr. Abdul Hakk, K.S.
" Kodandera Mandanna.
" H. Narasimhamurti Rao.

Lower Subordinate Service.

29 Surveyors, etc.

This party completed the detail survey on the 1-inch scale of sheets $57\frac{G}{3, 4, 7, 11, 15}$, $57\frac{H}{1, 2, 6}$, $57\frac{P}{1, 3, 4, 5, 6, 7, 8, 11, 12, 15, 16}$, with the exception of small areas of reserved forests in $57\frac{P}{3, 4, 7, 11, 15}$ which were surveyed by the party on the 2-inch scale and of sheet $57\frac{H}{6}$ and of a portion of sheet $57\frac{H}{2}$ which were surveyed by the Training Section on the 2-inch scale. The party also undertook the triangulation of sheets $57\frac{O}{1, 2, 5, 6, 9, 10, 13, 14}$.

The general nature of the country consists of forest-clad hills, mostly reserved forests, lower rocky hills covered with scrub or devoid of vegetation, open cultivated plains with detached rocky knolls and rocky outcrop and the open undulating plateau land of Mysore. The whole country is well served with main and other roads in a fairly good state of repair, rendering access to any part of it easy and convenient. Large sized bullock carts are obtainable everywhere but coolies are difficult to get as they are much in demand by the cultivators of these parts.

The field season opened between the 2nd October and the 1st December 1914 and closed between the 7th March and the 5th May 1915; the work in sheets 57 G, 57 H, commenced and ended on earlier dates than the work in sheet 57 P. As the party in October 1913 experienced the full force of the north-east monsoon while working in the locality adjoining this season's programme in Madras, the departure of the party was delayed a month with great advantage to the work. It is not advisable to take the field in these parts of Madras before November or to prolong it after the end of April when the heat becomes unbearable. The field head-quarters was at Bangalore.

The health of the party throughout was good.

Topography.—The country surveyed in Madras breaks away from the high hills mostly covered with reserved forests of the Javādi range on the extreme west limit of the work, to alternations of flat ground and lower rocky hills covered with scrub or devoid of vegetation and finally to extensive and highly cultivated plains, containing large villages sheltered in dense groves of palmyra palm and other trees, and only broken here and there by detached rocky knolls and outcrop of rock and sand hills on the coast. The area in Madras embraces many places of historical interest such as Arcot, Arni, Wandiwāsh, Gingee, Vellore and several towns. The Pālār river with its tributary the Cheyyār traverses a part of the work. The country is covered with a network of communications. After a good monsoon the low ground in Madras, well served with tanks and wells, is extensively and constantly under paddy cultivation to the end of April and as many as three harvests are reaped; this hampers the work to the extent of surveyors having to go treble the distance they would ordinarily take. Open and undulating plateau land, broken here and there by a group of fairly high hills mostly covered with reserved forests and rising abruptly to a height of 4,847 feet, marks the features of the ground surveyed in Mysore. This country is well served with many main roads, etc., rendering communication easy. Several towns and the famous fortified hill of Nandidroog fall in the work in Mysore.

The work was distributed as follows :—

No. 1 Camp.—Under Mr. West with Mr. Littlewood and 6 surveyors carried out revision survey on the 1-inch scale of 1,640 square miles in sheets $57\frac{G}{3, 4, 7, 11}$, $57\frac{H}{1, 2}$.

No. 2 Camp.—Under Mr. Butterfield with Mr. Harihara Iyer and 6 surveyors carried out survey on the 1-inch scale of 1,068 square miles and supplementary survey on the 1-inch scale of 88 square miles in sheets $57\frac{P}{1, 5, 6, 7}$.

No. 3 Camp.—Under Mr. Pollett with 8 surveyors carried out survey on the 1-inch scale of 1,324 square miles, supplementary survey on the 1-inch scale of 34 square miles and survey of reserved forests on the 2-inch scale of 10 square miles in sheets $57\frac{P}{8, 11, 12, 15, 16}$.

No. 4 Camp.—Under Mr. Abdul Hakk with 6 junior surveyors carried out survey on the 1-inch scale of 529 square miles, revision survey on the 1-inch scale of 289 square miles, supplementary survey on the 1-inch scale of 12 square miles and survey of reserved forests on the 2-inch scale of 42 square miles in sheets $57\frac{G}{15}$, $57\frac{P}{3, 4}$.

In addition to the above an area of 387 square miles of survey on the 2-inch scale in sheets $57\frac{H}{2, 6}$, which was carried out by the Training Section during 1913-14 and 1914-15, was accepted by the officer in charge of the party who satisfied himself that revision was unnecessary. This area has been included in the total outturn of the party but has not been included in the figures giving the average monthly outturn per man or the cost-rate per square mile, for the 2-inch survey.

The 1-inch survey in Madras was considerably helped by the work of the Madras Survey Department which was found accurate and satisfactory; from the standard sheets, supplied on thin bankpost paper, transfer of the work in blue was carried out by the surveyors as the work progressed, this was gone over and checked by them as rigorously as if 1-inch original work. For the revision survey the 1-inch maps of the old Mysore topographical survey were

found very accurate in detail but had to be considerably supplemented and recontoured to bring them up to the modern standard, the country was ideal and presented no difficulty. Black tracing prints of the above sheets for survey were procured and transferred piecemeal on the plane-table as work progressed, with the usual rigorous checking by surveyors as if original work. For the 1-inch supplementary survey the 4-inch forest surveys were first reduced to the $1\frac{1}{2}$-inch scale on blue prints, these were inked up in detail and the shape of the ground also indicated so as to help when recontouring; each print was then adjusted by the trigonometrical points common to it and to a $1\frac{1}{2}$-inch projected and plotted sheet; the whole was finally reduced and printed on to the plane-table sections. This class of survey was checked and supplemented where necessary and recontoured. The 2-inch reserved forest survey was located mostly in open flat country with low rocky hills within commanding distance rendering survey easy, where the forest was dense traversing with the plane-table and chain had to be resorted to and it was begun and closed on fixings obtained at intervals.

The full programme of the party, amounting to 5,423 square miles, was completed. The outturn of the 1-inch survey, of the 1-inch revision survey, of the 1-inch supplementary survey and of the 2-inch survey was 2,921, 1,929, 134 and 439 square miles, respectively, the average monthly outturn per man was 26·8, 30·0, 51·7 and 7·0 square miles respectively and the cost-rate per square mile was Rs. 9·5, Rs. 9·0, Rs. 6·0 and Rs. 30·9, respectively.

Triangulation.—The country triangulated extended from the Eastern Ghāts, locally known as the Tirupati hills, on the west to the undulating and flat country on the east and presented no difficulties.

Mr. Kodandera Mandanna completed an area of 1,155 square miles in sheets 57 $\frac{O}{1, 2, 5, 6}$ and Mr. Narasimhamurti Rao an area of 1,154 square miles in sheets 57 $\frac{O}{9, 10, 13, 14}$. In addition to the points now fixed about 300 points, fixed by triangulation when the reserved forests in this area were surveyed, will also be utilised.

Charts on the $\frac{1}{4}$-inch scale, supplied by the Madras Survey Department containing their traverse stations and trijunctions, enabled the triangulators to fix the same and to check the accuracy of the work to be surveyed topographically. Several traverse stations were fixed and compared with the Madras Survey values and are in agreement. This agreement confidently entitles the surveyors to utilise all village trijunctions in the plains, where trigonometrical points are not available or too far apart, as beginning and closing points for their traverses. The programme included sheet 66 C, but it was found that there already exists sufficient material in this sheet without any new work being necessary.

The total outturn was 2,309 square miles and the cost-rate per square mile was Rs. 7·0.

Recess duties.—The fair mapping was divided among four sections as follows:—

No. 1 Section.—Under Mr. West, sheets 57 $\frac{G}{3, 4, 7, 11, 15,}$, 57 $\frac{H}{1, 2}$.

No. 2 Section.—Under Mr. Butterfield, sheets 57 $\frac{P}{1, 5, 6, 7}$.

No. 3 Section.—Under Mr. Morton, sheets 57 $\frac{P}{11, 12, 15, 16}$.

No. 4 Section.—Under Mr. Abdul Hakk, sheets 57 $\frac{H}{6}$, 57 $\frac{P}{3, 4, 8}$.

No. 4 Drawing Office lent some draftsmen to assist the fair mapping. Seven sheets have been submitted to the Superintendent and the fair

mapping of the remaining 12 sheets will be completed by the end of the recess season.

The total area of fair mapping was 5,423 square miles and the cost-rate per square mile was Rs. 4·5.

The computations of the triangulation carried out during the field season, together with some arrears from the previous year, were completed under the supervision of Mr. Littlewood.

During previous years the work on the triangulation charts of this party has been allowed to get considerably in arrears. The preliminary triangulation charts 48 L, O, P, 57 D, H, L were received from the Superintendent of the Trigonometrical Survey and were put in hand ; of these, charts 48 L, 57 L are near completion and the remainder are still in the rough abstract stage embracing work solely done by the party and requiring incorporation of the Mysore topographical triangulation, etc., they will be taken up on return of the party to recess in 1916. It is hoped that the triangulation charts will be brought up to date by the end of next year.

No. 8 PARTY (MADRAS).

BY MR. W. F. E. ADAMS.

This party completed the detail survey on the 1-inch scale of sheets $58\frac{D}{7, 8}$, $58\frac{H}{1, 2}$ and portions of sheets $58\frac{D}{14}$, $58\frac{H}{3}$ and on the $1\frac{1}{2}$-inch scale of sheets $58\frac{D}{9, 15}$ and the remaining portions of sheets $58\frac{D}{14}$, $58\frac{H}{3}$. The party also undertook the triangulation of sheets $58\frac{H}{9, 15}$ and of portions of sheets $58\frac{H}{5, 6, 10, 14}$ and carried out theodolite traversing in sheets $58\frac{D}{14, 15}$, $58\frac{H}{3, 4, 8}$.

PERSONNEL.

Imperial Officers.

Major L. C. Thuillier, I.A., in charge from 9th November to 3rd December 1914.
Major C. M. Browne, D.S.O., R.E., in charge to 21st October 1914.

Provincial Officers.

Mr. W. F. E. Adams, to 21st October 1914, in charge from 22nd October to 8th November 1914, from 9th November to 3rd December 1914 and in charge from 4th December 1914.
Mr. S. F. Norman.
" J. H. Williams.
" P. Kennegy.
" M. Mahadeva Mudaliar, M.A.

Upper Subordinate Service.

Mr. Anantarao Dhondiba Mandhre, R.S.
" K. Narayanasvami Chetti.
" P. S. Vengusvami.

Lower Subordinate Service.

36 Surveyors, etc.

The general nature of the country is very varied in character and extends from the densely inhabited and intricate country along the coast to the high range of mountains separating the Travancore State from the Tinnevelly district, most of the high ground is forest-clad, uninhabited and difficult of access.

The field season opened on the 12th December 1914 and closed on the 10th June 1915. The party proceeded to, and returned from, the field by special trains, but owing to a breach of the railway near Tinnevelly due to floods, the party was delayed for two days on the way to the field. The field head-quarters was at Shencottah.

The *health of the party* was fair considering the climatic conditions, men working in the high range suffered a good deal from the cold and rain, while in the dense forests leeches and wild elephants were very troublesome.

Topography.—The nature of the country surveyed varies greatly, along the coast the country is undulating, enclosed and densely populated, while the

high range of mountains, separating the Travancore State from the Tinnevelly district and rising to a height of over 6,000 feet, is mostly covered with dense forest, uninhabited and difficult of access. The Tinnevelly plain is well cultivated and is covered with small tanks.

The work was divided among four camps as follows :—

No. 1 Camp.—Under Mr. Norman with Messrs. Narayanasvami Chetti and Vengusvami and 6 surveyors completed the survey of sheets 58 $\frac{G}{7, 8}$ and afterwards assisted No. 4 Camp.

No. 2 Camp.—Under Mr. Williams with 8 surveyors surveyed sheet 58 $\frac{H}{1}$ and afterwards assisted No. 3 Camp. The country in this sheet is uninhabited and very difficult of access, no labour or transport was procurable locally and, as no provisions were obtainable, complete arrangements had to be made by collecting supplies in suitable places.

No. 3 Camp.—Under Mr. Mahadeva Mudaliar with 10 surveyors surveyed sheets 58 $\frac{D}{9, 14, 15}$, the country near the coast in these sheets is covered with huts, but only those of a more or less permanent character were surveyed. The important towns of Quilon and Trivandrum were surveyed by this camp.

No. 4 Camp.—Under Mr. Anantarao Dhondiba Mandhre with 7 surveyors surveyed sheets 58 $\frac{H}{2, 3}$. The country in sheet 58 $\frac{H}{2}$ is similar to the country in sheet 58 $\frac{H}{1}$, one of the peaks being over 6,100 feet above sea level.

Owing to the extremely intricate nature of the country, the survey along the coast was carried out, as in previous years, on the 1½-inch scale. The work, on both the 1-inch and 1½-inch scales, was, except in the Tinnevelly plain, very difficult and the total area surveyed, amounting to 1,788 square miles, is consequently very small. The outturn of the 1-inch survey and of the 1½-inch survey was 1,280 and 508 square miles, respectively, the average monthly outturn per man was 13·8 and 8·5 square miles, respectively, and the cost-rate per square mile was Rs. 39·3 and Rs. 34·5, respectively. Although the monthly outturn of the 1-inch survey is considerably greater than that of the 1½-inch survey, the cost-rate of the former is actually greater than that of the latter, this is due to the exceptionally large expenditure incurred in the survey on the 1-inch scale on account of the very difficult nature of the country.

Triangulation.—The nature of the country triangulated is undulating and cultivated.

Mr. Kennegy, who suffered a good deal from fever, completed an area of 1,366 square miles in sheets 58 $\frac{H}{5, 6, 9, 10, 13, 14}$. The cost-rate per square mile was Rs. 10·8.

Traversing.—The country traversed is along the coast and of a very intricate nature.

One traverser, assisted by a surveyor, completed 144 linear miles in sheets 58 $\frac{D}{14, 15}$, 58 $\frac{H}{3, 4, 8}$. The cost-rate per linear mile was Rs. 24·8.

Recess duties.—The fair mapping was divided between two sections as follows :—

No. 1 Section.—Under Mr. Norman, sheets 58 $\frac{G}{7, 8}$, 58 $\frac{H}{1, 3}$.

No. 2 Section.—Under Mr. Williams, sheets 58 $\frac{D}{9, 14, 15}$, 58 $\frac{H}{2}$.

The fair mapping of all these sheets should be completed by the end of 1915. The fair mapping of sheets 58 $\frac{C}{12, 16}$, 58 $\frac{D}{13}$, arrears from the previous year, was completed and the sheets were submitted to the Superintendent.

The total area of fair mapping was 1,322 square miles and the cost-rate per square mile was Rs. 19·2.

The computations of the triangulation and traversing were completed under the supervision of Mr. Kennegy.

Triangulation charts 58 C, D are in hand.

EASTERN CIRCLE.

(*Vide* Index Maps 3 and 6.)

Summary.—The Circle was under the superintendence of Lieutenant-Colonel C. L. Robertson, C.M.G., R.E., up to the 23rd November 1914 and under Lieutenant-Colonel R. T. Crichton, C.I.E., I.A., from the 24th November 1914 up to the end of the Survey year.

An area of 5,056 square miles was surveyed consisting of:—

3,674	square miles of	1-inch survey.
223	ditto	1-inch supplementary survey.
372	ditto	1-inch revision survey.
531	ditto	2-inch survey.
225	ditto	2-inch skeleton survey.
31	ditto	4-inch survey.

No. 9 PARTY (BENGAL).

BY MR. J. SMITH.

The field programme of this party was considerably curtailed, involving the entire abandonment of detail survey and permitting only the execution of traversing in sheet 79 A.

PERSONNEL.

Imperial Officer.

Lieutenant-Colonel C. L. Robertson, C.M.G., R.E., in charge from 25th November 1914 till 22nd August 1915.

Provincial Officers.

Mr. J. Smith, in charge from 1st September 1915.
" Dhani Ram Verma.
" B. C. Newland, till 19th September 1915.
" L. B. Fitz-Gibbon, till 16th July 1915.
" Amar Krishna Mitra.
" V. P. Wainright, till 18th June 1915.
" W. P. Hales, till 18th June 1915.
" Dhirendra Nath Banerjee, B.A., till 23rd September 1915.

Upper Subordinate Service.

Mr. Dalbir Rai.
" Ram Singh, till 18th May 1915.

Lower Subordinate Service.

24 Surveyors, etc.

For this work one camp was formed under Mr. Fitz-Gibbon with Mr. Banerjee, 2 Upper Subordinates and 1 surveyor working under him.

The rest of the party were employed on $\frac{1}{2}$-inch mapping at Shillong.

The country traversed comprised parts of the Murshidābād, Burdwān and Nadiā districts falling in sheets 79 $\frac{A}{1, 2, 3, 5, 6, 7, 10, 11,}$ $\frac{A}{13 \text{ and } 14}$.

Altogether 1,244 linear miles of traverse were completed and 2,814 intersected points fixed, principally isolated trees, temples and signal posts on railway lines over an area of 2,870 square miles.

A training class in 1-inch plane-table survey was started on the 2nd January under Mr. Dhani Ram Verma and continued till the 8th May 1915. Three pupils from No. 12 Party and two from this party were given instruction in topography in the country round about Shillong and passed out well, with the exception of one man who was discharged.

The independent surveys executed by them compared very favourably with the topography as given on our 1-inch published maps, and amounted in all to an area of 63$\frac{3}{4}$ square miles, averaging 4 square miles per man per month.

Half-inch mapping.—Excluding 3 sheets, 64 $\frac{N}{S. E.}$, 73 $\frac{B}{S. W.}$, and 73 $\frac{F}{S. W.}$, which were drawn during the recess of 1913-14, the number of sheets allotted to this party was 15.

Three sections were formed to deal with this:—

Section No. 1.—Under Mr. Dhani Ram Verma with 7 surveyors had the drawing of sheets 73 $\frac{F}{N. E., S. E.}$, 78 $\frac{O}{N. E.}$ and $\frac{P}{S. E.}$.

Section No. 2.—Under Mr. B. C. Newland with 8 surveyors had the drawing of sheets 73 $\frac{\text{B}}{\text{N. E.}}$, 78 $\frac{\text{N}}{\text{N. E., S. W.}}$, $\frac{\text{O}}{\text{N. W.}}$ and $\frac{\text{P}}{\text{S. W.}}$.

Section No. 3.—Under Mr. A. K. Mitra with 8 surveyors had the drawing of sheets 73 $\frac{\text{F}}{\text{N. W., S. W.}}$, 78 $\frac{\text{N}}{\text{N. E., S. E.}}$, $\frac{\text{O}}{\text{S. E.}}$ and $\frac{\text{P}}{\text{N. W.}}$.

Two of the sheets started in 1913-14 have been sent in for publication and the third will shortly follow.

Of the sheets allotted to the party for completion during the year 1914-15, six were started in January, two more were taken up in February, two more in March, three more in April and the last in May.

Three have been finally examined by the section officers and are with the Officer in charge of the party for his examination before submission for publication, six are finished in drawing and are being finally examined by the section officers, and six are in hand in various stages of completion.

Owing to the many changes that have occurred in the personnel of the party, the examination has been greatly retarded.

The computations of the traversing done in the field season have been completed by Mr. Banerjee with Mr. Dalbir Rai and 3 computers working under him.

No. 10 PARTY (UPPER BURMA).

BY MAJOR E. T. RICH, R.E.

The recess office of the party closed in Maymyo on October 17th 1914 and opened in Myitkyinā on October 28th, 1914.

The office at Myitkyinā was closed on May 31st 1915 and the recess office was opened in Maymyo on June 2nd 1915, where it remained for the rest of the year.

The country under survey lay in the Myitkyinā, Kathā and Putao districts of Upper Burma, nearly the whole area being covered with densely wooded hills and valleys, whilst great varieties in height were experienced, varying from 500 feet above sea level to nearly 14,000 feet above sea level.

PERSONNEL.

Imperial Officer.

Major E. T. Rich, R.E., in charge.

Provincial Officers.

Mr. J. Smith to 30th November 1914.
„ W. G. Jarbo.
„ H. B. Simons.
„ V. W. Morton, to 13th June 1915.
„ Asmat-Ullah Khan, K.S., to 24th October 1914 and from 1st June 1915.
„ C. B. Sexton, till 15th July 1915.
„ A. F. Murphy.

Upper Subordinate Service.

Mr. Hayat Muhammad, K.S., to 28th February 1915, and from 1st September 1915.
„ Maung Kyaw Nyein.
„ Dhirendra Nath Saha from 20th October 1914.
„ Ram Prasad promoted from the Lower Subordinate Service from 1st July 1915.

Lower Subordinate Service.

26 Surveyors, Draftsmen, etc.

The *health of the party* was not very good during the winter season, as there were numerous cases of malaria from which three *khalāsis* died.

Topography.—Surveys were completed over an area of 2,068 square miles at a cost of Rs. 76,879 in sheets 92 $\frac{\text{C}}{\text{12, 16 (part)}}$, 92 $\frac{\text{D}}{\text{1, 2, 5 (part), 9}}$, 92 $\frac{\text{G}}{\text{9, 13 (part)}}$ and in parts of 6 frontier sheets.

This area was surveyed as follows :—

1,833	square miles of new	1-inch	survey.
178	ditto	2	ditto.
57	ditto		1-inch revision survey.
2,068	square miles.		

The party was divided into three survey camps under Messrs. W. G. Jarbo, H. B. Simons, and V. W. Morton, respectively, whilst Mr. Maung Kyaw Nyein was in charge of a camp of instruction for 3 pupils and 4 soldier surveyors.

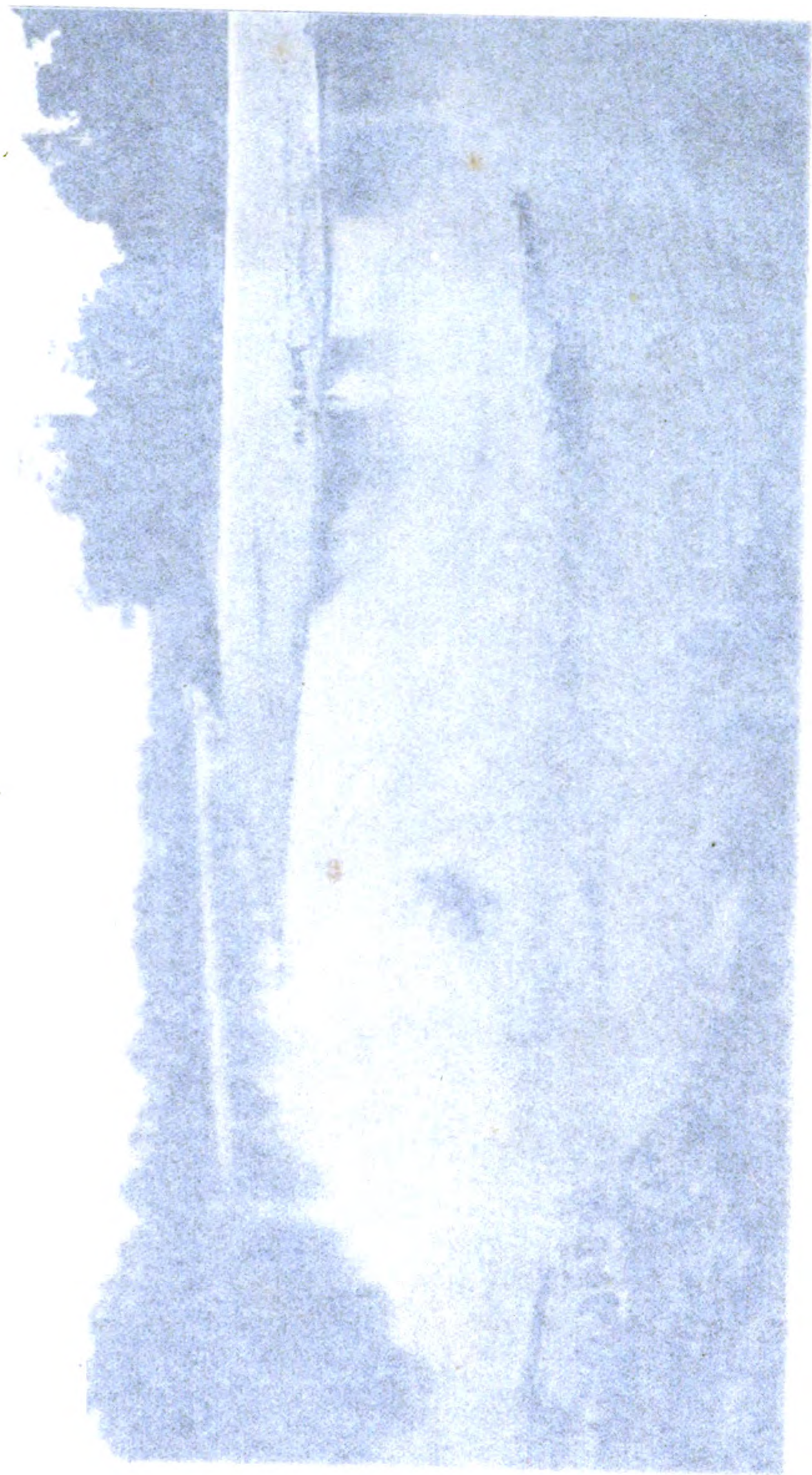
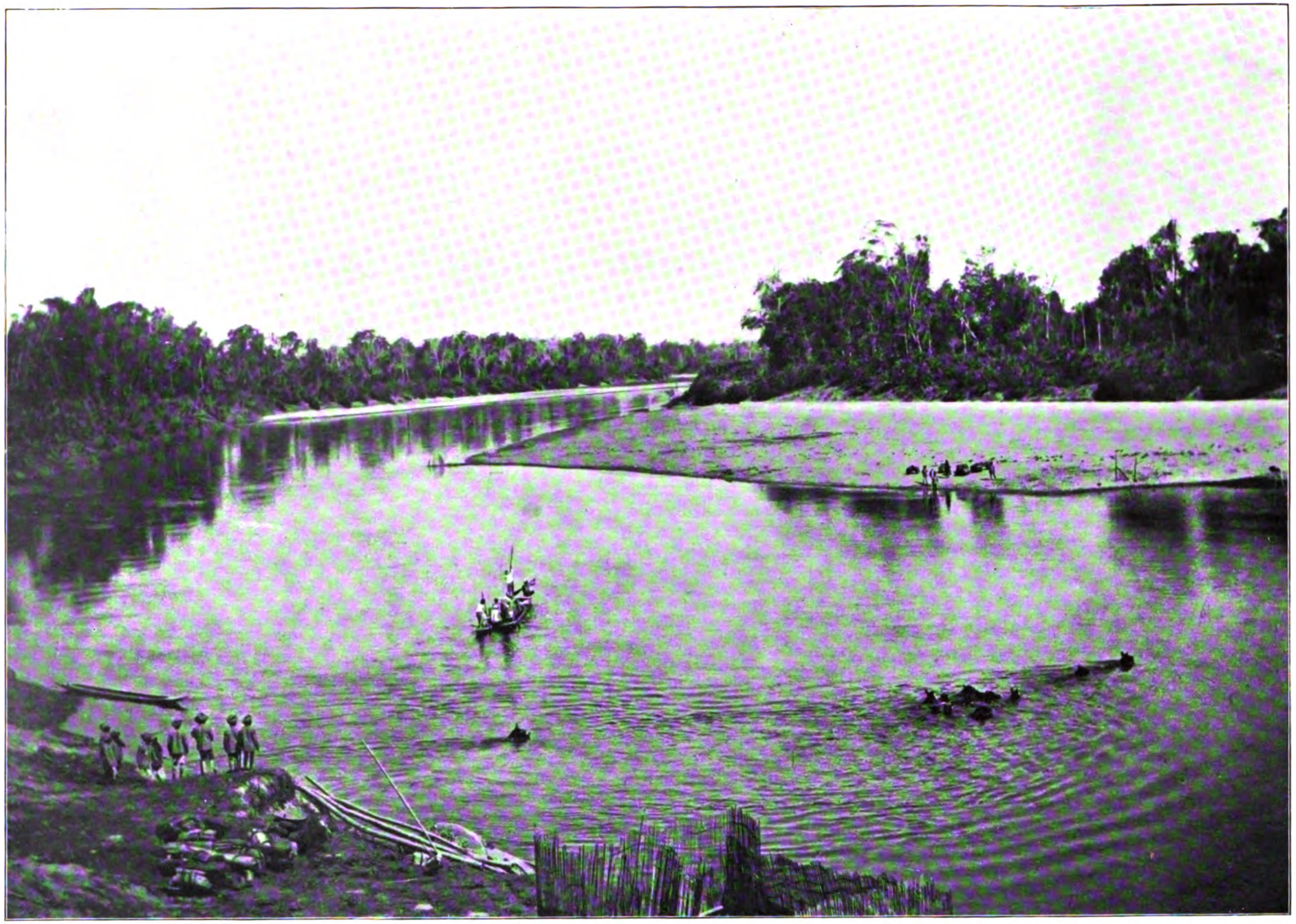


Plate 6.



Survey camp crossing the Irrawaddy near Myitkyina, N. E. Frontier of Burma.

Reproduced from a photograph by Major E. T. Rich, R.E.

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1916.

Camp No. 1.—In charge of Mr. W. G. Jarbo with 3 surveyors completed an area of 472 square miles on the 1-inch scale along the frontier of which details are given in a separate report.

Camp No. 2.—In charge of Mr. H. B. Simons with one Provincial Officer, Mr. A. F. Murphy, two Upper Subordinates, Messrs. Hayat Muhammad, K.S., and D. N. Saha and 8 surveyors, completed an area of 975 square miles on the 1-inch scale and 43 square miles on the 2-inch scale in sheets 92 $\frac{C}{12}$, $\frac{D}{9}$, $\frac{G}{9}$ and parts of sheets 92 $\frac{C}{16}$ and $\frac{G}{13}$.

This area consists of thickly wooded low-lying hills except in the parts adjacent to the railway line in the centre of sheet 92 $\frac{C}{12}$ and north-west corner of sheet 92 $\frac{D}{9}$ which are highly cultivated with populous villages.

Camp No. 3.—In charge of Mr. V. W. Morton with 7 surveyors completed an area of 578 square miles in sheets 92 $\frac{D}{1, 2}$ and part of sheet 92 $\frac{D}{6}$ consisting of 386 square miles of new survey on the 1-inch scale, 135 square miles of reserved forests on the 2-inch scale and 57 square miles of 1-inch revision survey over forests previously surveyed on the 4-inch scale.

The country in this camp is low-lying and thickly wooded with very few inhabitants, the progress was, therefore, very slow as nearly all the work had to be done by chaining.

In addition to the above, Surveyor Shaikh Abdullah was seconded under the Burma Government from 1st October 1914 to 31st May 1915 and surveyed 600 square miles on the $\frac{1}{2}$-inch scale in the north of the Putao district in parts of sheets 91 $\frac{H}{8, 11, 12, 16}$ and 92 $\frac{E}{9}$.

This area has been excluded from the detail survey area given for the party and also from the calculation of cost-rates as the surveyor was seconded from the party.

Triangulation.—New triangulation was completed over an area of 3,320 square miles at a cost of Rs. 23,488, including the computations.

(*a*) Mr. C. B. Sexton triangulated an area of 1,070 square miles in sheets 92 $\frac{C}{3, 4, 7, 8}$ of the Myitkyinā district.

(*b*) Mr. Ram Prasad triangulated an area of 2,250 square miles in sheets 92 $\frac{F}{3, 4, 7, 8, 10, 11, 12}$ of the Putao district and in sheets 92 $\frac{F}{14, 15, 16}$ and two sheets of unadministered territory.

Great credit is due to the arrangements made by Mr. Ram Prasad who was working under great difficulties, over seven days march from his base in Myitkyinā, whence all provisions, etc., had to be carried. He managed his own arrangements entirely by himself.

The country triangulated by both triangulators is of the same nature as last year consisting of thickly wooded hills and deep valleys sparsely inhabited.

Traversing.—During the field season, Mr. H. B. Simons was in charge of all traversing and during the recess he superintended the traverse computations.

Four-inch theodolite boundary traverses were completed round the Maingnsung, Nammun, Namma, Indawgyi, Nanyiṅka and Namaw reserved forests of the Myitkyinā district and the Nankobin reserved forest in the Upper Chindwin district in sheets 92 $\frac{C}{3, 4, 8}$, $\frac{D}{5}$ totalling 164 linear miles.

The outturn was small owing to the dense jungle encountered everywhere which made progress very slow.

The total cost of traversing and its computations amounts to Rs. 12,923.

Recess Duties.—The fair mapping was divided into two sections.

No. 1 Section.—In charge of Mr. W. G. Jarbo, assisted by Mr. A. F. Murphy and Mr. D. N. Saha, drew sheets 92 $\frac{G}{9,13}$ and 5 frontier sheets, of which only one frontier sheet will be ready for publication before the party takes the field.

No. 2 Section.—In charge of Mr. Asmat-Ullah Khan, K.S., assisted by Mr. Maung Kyaw Nyein, drew sheets 92 $\frac{C}{12}$, $\frac{D}{1,2,9}$ and 2 frontier sheets, of which all but one sheet will be sent for publication before the party takes the field.

The computations of the season's triangulation and traversing were completed during the recess in charge of Mr. H. B. Simons assisted by Mr. C. B. Sexton, Mr. Ram Prasad, and one computer.

Outturn and cost-rates.—The cost-rates show a large increase all round except for triangulation and fair mapping which show a decrease.

This increase of cost-rates is entirely due to the personnel of the party during the field season having been made up of all the surveyors from Nos. 10 and 11 Parties who were poor draftsmen, whilst the good draftsmen, who were also in most instances the best surveyors, were left in Maymyo to do $\frac{1}{2}$-inch mapping.

This reduced the outturn by over fifty per cent. and as the total cost was very little changed, the cost-rates for detail survey are fifty per cent. higher than those of last year.

The cost-rate for 1-inch survey is increased by Rs. 11·18 per square mile, being Rs. 33·56 per square mile.

For 2-inch survey the cost-rate is increased by Rs. 29·09 per square mile, being Rs. 83·6 per square mile.

For triangulation the cost-rate is very satisfactory being reduced by Rs. 1·34 per square mile. It is Rs. 7·07 per square mile.

For 4-inch boundary traverses the cost-rate is increased by Rs. 7·66 per linear mile, being Rs. 78·79 per square mile.

For mapping the cost-rate is reduced by Re. 0·57 per square mile, being Rs. 6·94 per square mile.

No. 11 PARTY (UPPER BURMA).

By Mr. J. O. Greiff.

In accordance with the general scheme of retrenchment, this party did not take the field for regular survey operations in the districts of Tavoy and Mergui, but was employed instead at recess quarters, Maymyo, on $\frac{1}{2}$-inch mapping.

PERSONNEL.

Imperial Officer.

Captain L. G. Crosthwait, I.A., in charge up to 1st December 1914.

Provincial Officers.

Mr. J. O. Greiff, in charge from 2nd December 1914.
" Asmat-Ullah Khan, K.S., from 25th October 1914 to 31st May 1915.
" A. M. Talati, L.C.E.
" F. E. R. Calvert, up to 15th July 1915.
" A. J. Booth.
" R. M. Wyatt, up to 15th July 1915.

Upper Subordinate Service.

Mr. Lachman Daji Jadu, R.B., from 17th November 1914.

Lower Subordinate Service.

32 Surveyors, Draftsmen, etc.

Topography.—Two surveyors were employed in completing the revision survey, on the 1-inch scale, of 315 square miles of country in sheets 93 $\frac{B}{8}$, 93 $\frac{C}{5,9}$. The country contained in these sheets and sheet 93 $\frac{B}{12}$ encircles the town of Maymyo, the town lying practically in the centre of the area. The sheets are in much demand both by the military and civil authorities.

To meet their requirements, their revision was started in the recess season of 1913-14 by No. 10 Party, and was taken over for completion by this party in the current field season. The 1-inch revision has been completed, and there remain only the reserved forest areas, which come under special survey next field season.

The country surveyed comprised parts of the Maymyo plateau and adjoining high hills, rising to over 3,000 feet in elevation, densely wooded and sparsely populated. The revision survey was directly under the supervision of the executive officer.

Triangulation.—Mr. Lachman Daji Jadu, and Surveyor Muhammad Yusuf Khan carried out a little supplementary triangulation for the purpose of fixing additional points, for the special forest surveys to be taken up next year, and for the closing of theodolite traverses.

Traversing.—The boundaries of reserved forests Baw, Baw Extension, Zibingyi-Tonbo, Kywetnapha and Nyaundauk, totalling 195 linear miles, were traversed by chain and theodolite. The first two reserves are to be surveyed on the special 4-inch scale. The total cost of this survey will be borne by the Forest Department. Some revision traversing, and connections of traverses with triangulation data, were also carried out along the boundaries of the Taungbyo and Sakangyi reserves. The boundaries of these reserves, totalling 128 linear miles, had been traversed in the preceding recess season by No. 10 Party. The computations, for 323 linear miles of traversing, and for the supplementary triangulation, were under the charge of Mr. A. M. Talati, who also supervised the preparation of the 4-inch forest boundary plots, and the correction and compilation of topographical data for preliminary triangulation degree charts. Nine such charts have been dealt with during the year.

Mapping.—The Maymyo drawing office attached to No. 10 Party was transferred to this party from 1st December 1914. The combined drawing staff of the party has been employed on $\frac{1}{2}$-inch and $\frac{1}{4}$-inch mapping.

Twelve $\frac{1}{2}$-inch sheets $84\ \frac{M}{N.W.}$, $92\ \frac{D}{S.E., S.W.}$, $92\ \frac{G}{S.E.}$, $92\ \frac{H}{N.W., S.W., N.E., S.E.}$, $92\ \frac{D}{S.W.}$, $92\ \frac{G}{S.W.}$, $92\ \frac{L}{S.W., S.E.}$, were allotted to the party for completion during the year. The first eight of these were completed and submitted for publication by the end of September, and the remaining four are well advanced. As the combined blue prints of the component 1-inch sheets were not received till the end of December 1914, the $\frac{1}{2}$-inch mapping was not actually started till January 1915. In the interval, however, much practice work was done in the finer class of drawing needed for $\frac{1}{2}$-inch mapping. The mapping was distributed between three sections, under Messrs. Asmat-Ullah Khan, F. E. R. Calvert, and R. M. Wyatt.

Section I.—Was under Mr. Asmat-Ullah Khan until the 1st June 1915, when it was taken over by Mr. A. J. Booth. It is responsible for the completion of $\frac{1}{2}$-inch sheets $92\ \frac{H}{N.E.}$ and $92\ \frac{D}{S.W.}$; also the compiling and mapping of degree sheets 84 N, 93 E, 93 I, 93 J. These are in various stages of advancement. It is hoped to submit 84 N for publication before the close of the year.

Sections II and III.—Under Messrs. Calvert and Wyatt, completed the mapping of sheets $84\ \frac{M}{N.W.}$, $92\ \frac{D}{S.E.}$, $92\ \frac{G}{S.E.}$, $92\ \frac{H}{N.W., S.W., S.E.}$. On Messrs. Calvert and Wyatt being appointed to the Indian Army Reserve of Officers, the two sections were combined, and placed under the supervision of

Mr. Lachman Daji Jadu, assisted by draftsman Radha Krishna, who carried out almost all the preliminary examinations.

The total area mapped is 8,671 square miles which is very creditable, considering the staff was new to this class of mapping, that is, drawing to a smaller scale from a larger. It was necessary to prepare detailed working plans for the draftsmen to follow. A large amount of compilation work was necessary, to guide the draftsman as to how detail might be eliminated and generalized, to avoid overcrowding the resulting map and detracting from the character of topographical features. The ½-inch scale is a difficult scale, coming as it does between the 1-inch and the ¼-inch, the tendency being either to show too little or too much.

Cost-rates.—The high rate for traversing is due to heavy clearing on the forest boundaries, which were not cleared by the Forest Department.

The revision survey was practically a new survey, as the old work was found to be very much out, and could not be accepted.

The high rate for ½-inch mapping is due to slow progress at the start, and to no field work; the consequence of the latter being that the cost of the supervising staff has been debited almost entirely to mapping.

No. 12 PARTY (ASSAM).

By Lieutenant-Colonel A. Mears, I.A.

PERSONNEL.

Imperial Officer.

Lieutenant-Colonel A. Mears, I.A., in charge.

Provincial Officers.

Mr. W. Skilling.
„ Pramadaranjan Ray, R.S.
„ E. M. Kenny.
„ P. C. Mitra, B.A.
„ H. H. Creed.

Upper Subordinate Service.

Mr. Nanak Chand Puri, B.A., till 21st May 1915.

Lower Subordinate Service.

42 Surveyors, etc.

The party continued work in the Darrang, Sibsāgar and Nowgong districts, the area of operations extending from the Daflā Hills on the north to the Nāgā Hills on the south and included to the east the greater portion of the Tezpur and Golāghāt sub-divisions of districts Darrang and Sibsāgar, situated in sheets $83 \frac{F}{1, 5, 6, 7, 9, 10, 11, 12, 14, 15}$. The programme was carried out on the 1-inch scale except for the Mīkīr Hills, Kaliāni, Panbāri, Upper and Lower Daigurung, Nāmbar and Dayāng reserves, comprising an area of 332 square miles, which were surveyed on the 2-inch scale. The special survey on the 2-inch and 4-inch scales of the Upper Dihing reserve, started a couple of seasons previously, was completed; the work progressed well and the detail camp employed on this survey was available early in February for the ordinary topographical operations of the party.

The country under survey was similar in most respects to that of past seasons.

The Mīkīr Hills which rise to an elevation of nearly 4,500 feet are densely wooded. The country to the south of these hills lying between them and the Nāgā Hills comprises what is known as the Nāmbar Forest, a tract of almost primeval tree growth intermixed with large areas of cane and swamp; endeavours are being made to open up this country by free grants of land to settlers but so far with little success. The valley proper of the Brahmaputra, where not cultivated, is covered for the most part with impenetrable "khagra" grass from 10 to 20 feet high. The field season started about the middle of

November and finished early in May when the rains had already commenced and the programme was completed with some difficulty. The health of the party was only fair, considerable numbers of men suffering from malaria and leech-bite ulcers, 4 *khalāsis* died in the field, 2 of the deaths being from cholera and smallpox. Two surveyors and a traverser died at their homes whilst on leave during the recess.

Topography.—The programme of detail survey was carried out by 4 camps and a training section under the charge of Messrs. Pramadaranjan Ray, Rai Sahib, E. M. Kenny, P. C. Mitra, H. H. Creed, and Surveyor Ghulam Haidar.

Mr. Pramadaranjan Ray with a camp of 10 surveyors and 3 pupils surveyed nearly 3 sheets, a considerable portion of the area being 2-inch forest survey. Mr. E. M. Kenny with an establishment of 8 surveyors completed an area equivalent to 3¼ sheets. To Mr. P. C. Mitra with a strength of 7 surveyors was allotted the special 4-inch and 2-inch survey of the Upper Dihing reserve and the completion of one standard sheet.

Mr. H. H. Creed with 3 surveyors, and plane-tabling himself, surveyed 1¼ sheets. The training section under Surveyor Ghulam Haidar with 5 soldier surveyors and one pupil completed one sheet. Nearly half the area surveyed was hilly and comprised the Mīkīr Hills which rise from the plains level of 300 feet to close on 4,500 feet ; except where they have been "jhoomed" these hills are densely wooded and the slopes as a rule exceedingly steep. To the north of the Brahmaputra river tea is extensively grown and there are a considerable number of tea gardens along the foot of the northern and eastern slopes of the Mīkīr Hills. Good cold weather roads exist throughout the plains and the Assam Bengal Railway traverses the Nāmbar forest in the south-east of the area topographically surveyed.

In the Mīkīr Hills communications may be said to be non-existent ; the only path of any importance is along the Kaliāni valley over which it was possible to take loaded elephants for a certain distance, elsewhere coolies are the only form of transport. Supplies and labour were obtained fairly easily on the whole ; in the Nāmbar forest surveyors' squads had to be strengthened owing to the heavy line clearing and paucity of villages. The party's outturn of detail survey comprised 2,064 square miles on the 1-inch scale, 353 square miles of reserved forests surveyed on the 2-inch scale (this includes 21 square miles of special forest survey) and 31 square miles of special forest survey on the 4-inch scale. In view of the densely wooded and difficult nature of the major portion of the country these outturns may be considered satisfactory.

The survey cost-rates for the year compare favourably with those of the previous season, the slight increase in the 1-inch rate is due to the country being less open and the small outturns given by the training section. The cost-rate for the 4-inch special forest survey is very considerably lower than that for the previous year, this rate may be accepted as satisfactory for the nature of the country under survey.

Triangulation.—A small area of about 300 square miles was triangulated in the Nāgā Hills by Mr. V. P. Wainright in order to fix sufficient points for the 1-inch topographical survey of the hilly portions of sheets $83\frac{J}{3,6}$. The work was based on the Assam Longitudinal and Nāgā Hills series but could not be closed on any principal station on account of the impossibility of clearing rays to the low-lying river stations of the first named series ; this omission

will be rectified when the survey of the remainder of the Nāgā Hills is carried out. The work was completed early in January and beyond entailing very heavy clearing for stations calls for no special comment. The triangulation cost-rate may be considered normal for densely wooded country and is slightly lower than the rate for season 1912-13.

Traversing.—An area of some 2,100 square miles was traversed in advance for 1 and 2-inch detail survey. In the open plains, already surveyed cadastrally, the work was entirely confined to obtaining sufficient heights for the topographical survey of this area. In the reserved forests and wooded country traverses had to be run considerably closer together and entailed very heavy line clearing. A total of 858 linear miles of traversing was carried out during the season which includes the traversing of artificial forest boundaries. Selected stations such as mile stones, bench marks, masonry bridges to the number of 366 were permanently marked and in addition 590 zinc cylinders were embedded. The country traversed differs little from that surveyed in detail.

The cost-rate for traverse survey is less than half that for the previous season and may be accepted as normal for the wooded and high grass covered plains of Assam.

Recess duties.—The fair mapping of the season's detail survey, consisting of nine and a half 1-inch sheets was distributed between 3 drawing sections under the supervision of Messrs P. Ray, Rai Sahib (3 sheets), E. M. Kenny ($3\frac{1}{2}$ sheets), P. C. Mitra (3 sheets); areas surveyed by these assistants in the field being, as far as possible, allotted them to fair-map. The work has progressed very satisfactorily, sheets 83 $\frac{F}{1, 7, 9, 11}$ were submitted for publication before the close of the survey year and the remaining sheets will be completed before the party moves into the field. In addition to the above the following sheets have been submitted for publication during the year under report, 83 $\frac{B}{10, 11, 14, 15}$, 83 $\frac{F}{2, 3, 8}$ which make a total of eleven 1-inch sheets for the year. The fair mapping cost-rate amounts to Rs. 8·6 per square mile which is practically the same as that for the preceding year. The triangulation and traverse computations of the season have been completed, the work proving satisfactory.

ANDAMANS DETACHMENT.

BY LIEUTENANT-COLONEL R. T. CRICHTON, C.I.E., I.A.

PERSONNEL.

Provincial Officer.

Mr. E. Claudius in charge.

Lower Subordinate Service.

8 Surveyors.

The Andamans Detachment was composed of one assistant as officer in charge, eight surveyors, seventy-one *khalāsis*, and over two hundred convict labourers.

The number of linear miles of theodolite traversing done was 93, this was computed, plotted, and used as data for surveying the island of Baratang which falls in sheets 86 $\frac{D}{15, 16}$.

The total area surveyed on the 2-inch scale (skeleton survey with ridges) is 225 square miles, embracing part of Middle and South Andamans, in sheets 86 $\frac{D}{14, 15, 16}$.

Nature of the country is hilly, and very densely wooded, the low lands consisting principally of mangrove swamps. The tracts under survey are uninhabited except the island of Baratang which is frequented by hostile Andamanese called Jarawas, who move about in a state of nudity, armed with bows

and arrows. One surveyor's camp was attacked at dawn on the 25th November 1914 by a party of about fifteen, who wounded the sepoy on guard so severely that he took five months to recover and then had to be sent away on leave.

There is very little fresh water, and the climate is so enervating that a strong man feels exhausted, after only walking a mile or so, even along a cut line; also the whole place is infested with vermin. There was great difficulty in allocating rations on account of the rough sea. Having to work with convict coolies also gave a lot of trouble. Generally, the difficulties were of an exceptional nature and very heavy.

Recess duties.—The field sections were completed on return to recess quarters in Shillong. All field work was then sent to the Officer in charge Forest Map Office for the preparation by him of the maps for publication, and the detachment was then broken up; the members, not on leave, being transferred to the different parties of the Circle.

TABLE I.

OUTTURNS OF DETAIL SURVEY.

Scale.	Class of Survey.	Circle.	Party.	Locality.	Outturn.		Average number of fixings per square mile.	
					Total square miles.	Average per man per month. Square miles.	In situ (by resection).	Plane-table traverse.
$\frac{1}{4}$-inch .	Survey . .	N	No. 1	Kashmir . .	250	25·0	0·3	
$\frac{1}{2}$-inch .	Survey . .	S	No. 6	Hyderābād . .	5,096	80·1	6·0	
1-inch .	Survey . .	N	No. 1	Kashmir. . .	2,195	17·4	3·2	
		N	No. 2	Punjab . . .	844	50·9	...	13
		S	No. 5	Central Provinces and Berār.	3,070	30·2	8·7	1·6
		S	No. 6	Berār . . .	2,261	26·6	16·0	
		S	No. 7	Madras and Pondicherry.	2,921	26·8	9·1	
		S	No. 8	Madras . . .	1,280	13·8	5·9	14·9
		E	No. 10	Upper Burma .	1,833	27·8	5·0	2
		E	No. 12	Assam . . .	1,841	20·6	3·0	12
1-inch .	Re-survey .	N	No. 3	United Provinces .	1,359	27·7	16·0	4
		N	No. 4	Ditto .	3,467	33·48	25	
1-inch .	Revision Survey.	N	No. 2	Punjab . . .	2,550	38·3		
		N	No. 3	United Provinces .	1,669	31·2	11·0	3
		S	No. 5	Central Provinces and Berār.	1,357	58·7	3·1	0·3
		S	No. 6	Bombay and Berār .	261	29·0	15·0	
		S	No. 7	Mysore . . .	1,929	30·0	9·2	
		E	No. 10	Upper Burma . .	57	73·7	2·0	
		E	No. 11	Ditto . .	315	33	5	3·2

TABLE I—*concluded.*

OUTTURNS OF DETAIL SURVEY—*concluded.*

Scale.	Class of Survey.	Circle.	Party.	Locality.	Outturn. Total square miles.	Outturn. Average per man per month. Square miles.	Average number of fixings per square mile. In situ (by resection).	Average number of fixings per square mile. Plane-table traverse.
1-inch	Supplementary Survey.	S	No. 7	Madras	134	51·7	5·0	
		E	No. 12	Assam	223	19·9	...	13
1½-inch	Survey	S	No. 8	Madras	508	8·5	4·8	37·2
2-inch	Survey	S	No. 5	Berār	8	7·6	32·2	32·5
		S	No. 6	Do.	22	5·6	62·0	...
		S	No. 7	Madras and Mysore	439	7·0	19·6	
		E	No. 10	Upper Burma	178	5·9	15	46
		E	No. 12	Assam	332	7·9	3	62
2-inch	Survey (special forest.)	E	No. 12	Do.	21	7·9	...	70
2-inch	Skeleton Survey (uncontoured.)	E	Andamans detachment.	Andaman Islands	225	7·5	...	69
4-inch	Survey (special forest.)	E	No. 12	Assam	31	2·0	...	265
16-inch	Survey	N	No. 20	Sahāranpur Remount Depôt and Hāpur (Bābūgarh) Remount Depôt Cantonments.	9·22	1·53		
16-inch	Re-survey	N	No. 20	Meerut, Dehra Dūn and Landour Cantonments.	20·87	0·80		
64-inch	Survey	N	No. 20	Dehra Dūn Cantonment.	0·01	0·01		
64-inch	Re-survey	N	No. 20	Meerut Cantonment	0·49	0·10		
4-inch	Survey	N	Simla Survey detachment.	Koti State Forest (Simla.)	acres. 5,120·0	acres. 1,472·0	0·2	
8-inch	Survey	N	Do.	Simla	654·0	109·0	...	3·4
16-inch	Survey	N	Do.	Do.	830·0	295·0	1·0	
20 feet to 1 inch.	Survey	N	Do.	Bazaar Blocks (Simla)	32·0	6·4	...	61·0
125 feet to 1 inch.	Supplementary Survey.	N	Do.	Simla	2,700·0	32·0	...	5·0

TABLE II.

DETAILS OF TRIANGULATION AND TRAVERSING.

Scale.	Class of Survey.	Circle.	Party.	Locality.	TRIANGULATION.							INTERSECTED POINTS.		TRAVERSING.				
					Instrument used; diameter in inches.	Area in square miles.	Square miles to each point fixed.	Square miles to each height.	Stations fixed.	Triangular error in seconds.	Linear error per mile in feet.	Number of points fixed.	Linear error per mile in feet.	Area in square miles.	Linear miles of chaining.	Number of stations at which theodolite was set up.	Angular error per station in seconds.	Linear error per 1,000.
1-inch .	Triangulation.	N	No. 1	Kashmīr	6	1,350	5·60	5·72	23	10·16	0·21	587	1·2	...	...	...	...	...
1-inch .	Triangulation.	N	No. 2	Punjab	6	1,200	13	13	17	13	0·5	74	1·1	...	...	...	...	...
1-inch .	Traversing .	N	No. 2	Punjab	6	...	...	...	...	...	...	...	...	...	284	493	4·14	1·22
1-inch and 2-inch.	Triangulation.	N	No. 3	Kumaun Hills (United Provinces).	6	830	0·65	0·65	30	6·6	0·16	513	0·37	...	...	...	...	...
4-inch .	Triangulation.	N	No. 3	Kumaun Hills (United Provinces).	6	90	0·39	0·39	25	6·2	0·11	205	0·34	...	...	...	...	...
4-inch .	Traversing .	N	No. 3	Rāmnagar Forest Division .	6	...	...	...	...	...	...	...	...	492·72	397·90	4,824	3·7	·8
4-inch .	Traversing .	N	No. 3	Nainī Tāl Forest . .	6	...	...	...	...	...	...	...	...	45·18	106·83	1,226	2·7	3·8
1-inch	Traversing	N	No. 3	Tarai and Bhābar . .	6	...	...	...	...	...	...	...	...	212·38	334·65	1,808	3·7	·9
1-inch .	Traversing .	N	No. 4	United Provinces .	...	...	...	...	...	...	...	...	...	...	397	1,087	5	1
16-inch .	Triangulation and Traversing.	N	No. 20	Meerut, Landour, Dehra Dūn, Santa Cruz, Bannu, Peshāwar, Jullundur and Bakloh.	6 and 5	41	...	...	10	15	1	...	...	18·68	223·07	2,373	6	1·40
16-inch .	Triangulation and Traversing.	N	No. 20	Sahāranpur (Remount Depôt), Hāpur (Bābūgarh) Remount Depôt, Sanāwar and Kālka.	6	364	...	...	3	21	2	2	1	8·88	106·66	680	6	0·86

TABLE II—*concluded.*

DETAILS OF TRIANGULATION AND TRAVERSING—*concluded.*

Scale.	Class of Survey.	Circle.	Party.	Locality.	TRIANGULATION.									TRAVERSING.				
					Instrument used; diameter in inches.	Area in square miles.	Square miles to each point fixed.	Square miles to each height.	Stations fixed.	Triangular error in seconds.	Linear error per mile in feet.	Intersected Points. Number of points fixed.	Intersected Points. Linear error per mile in feet.	Area in square miles.	Linear miles of chaining.	Number of stations at which theodolite was set up.	Angular error per station in seconds.	Linear error per 1,000.
125 feet to 1-inch.	Traversing	N	Simla Survey Detachment.	Simla	...	...	...	...	...	...	...	...	...	4·0	39·3	604	1·78	1·25
1-inch	Survey	S	No. 5	Central Provinces, Berār, Bombay and Central India.	6	3,506	...	Computations not completed.				...	...	(a)	42	160	6·0	1·3
½-inch	Survey	S	No. 6	Hyderābād and Bombay*	5	7,335	13·7	14·5	47	8·0	0·19	500	0·51	...	...	...	...	...
1-inch	Survey	S	No. 7	Madras	6	2,309	9·1	9·4	36	6·1	0·18	248	0·56	...	...	...	...	...
1-inch	Survey	S	No 8	Madras	6	1,366	17·9	17·9	13	12·4	0·48	76	0·63	...	144	943	7·0	0·8
1-inch	Supplementary Survey.	E	No. 9	Bengal	...	...	...	...	...	...	...	...	...	2,870	1,244	2,179	3	0·7
1-inch and 2-inch.	Survey and Revision Survey.	E	No. 10	Upper Burma	6	3,320	11	11	19	10	0·12	317	0·5	...	164	4,393	6·8	1·7
2-inch and 4-inch.	Survey and Special Forest Survey.	E	No. 11	Upper Burma	6	221	2·3	2·3	19	6	0·23	67	0·32	...	221	3,705	3·7	2·7
1-inch and 2-inch.	Survey and Supplementary Survey.	E	No. 12	Assam	6	300	8·8	8·8	11	20·8	0·03	25	1·21	2,100	858	5,314	4·1	1·9
2-inch	Special Forest Skeleton Survey.	E	Andaman Islands.	Andaman Islands	5	...	...	...	...	...	...	...	...	104	93	1,907	0·7	2·4

(a) Included in area given under triangulation.

TABLE III.

COST-RATES OF SURVEY.

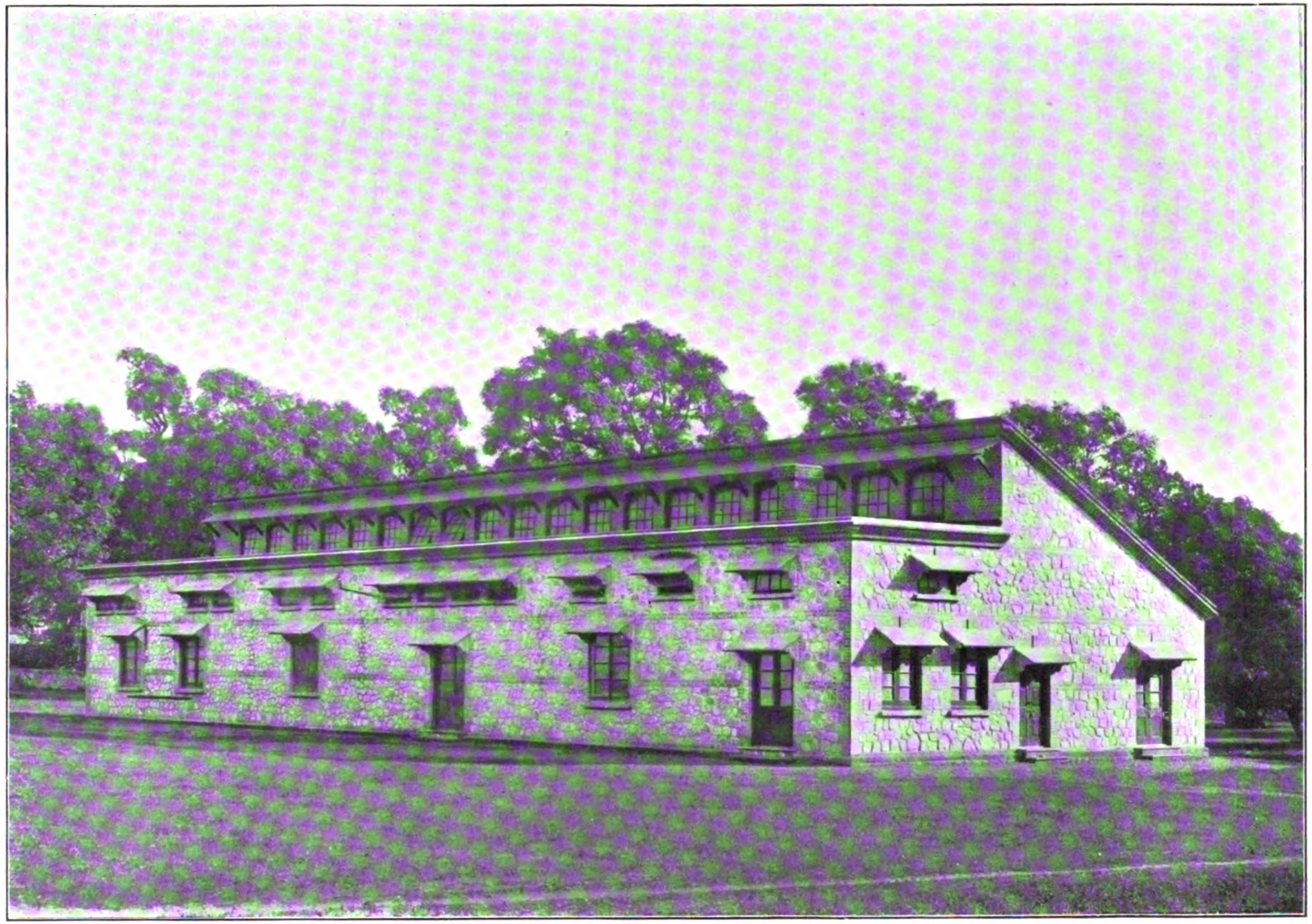
Circle.	Party.	Locality.	Cost-rate, rupees, per square mile. ¼-inch survey.	½-inch survey.	1-inch survey.	1-inch revision survey.	1-inch re-survey.	1-inch supplementary survey.	1½-inch survey.	2-inch survey.	4-inch survey.	16-inch survey.	64-inch survey.	Triangulation.	Cost-rate, rupees. Traversing per linear mile. Topographical.	Forest survey.	Fair mapping per square mile.	Total survey outturns on all scales, square miles.	Total cost of party. Rs.	Remarks.
N	No. 1	Kashmir	1·6	...	16·2	...	...	...	...	...	...	...	...	5·5	...	...	3·5	2,445	88,322* (a)	*Excludes Rs. 1,730 cost of move of Perso-Baluch Detachment. This Detachment was abolished and no work was done. (a) Includes Rs. 3,084 on account of pay, etc., of establishment of No. 4 Party employed on ½-inch mapping in No. 1 Party.
N	No. 2	Punjab	...	...	10·2	9·8	...	...	...	...	...	...	...	3·4	6·0	...	4·2	3,394	71,500	
N	No. 3	United Provinces . . .	...	...	...	8·5	8·2	...	...	...	...	...	...	10·0	31·7	15·5	4·6	3,028	85,998(b)	(b) Includes Rs. 8,845 on account of cost of Forest Survey debitable to Rāmnagar and Kumaun Forests.
N	No. 4	Ditto	...	...	...	...	9·3	...	...	...	...	...	...	...	13·0	...	7·2	3,467	66,354(c)	(c) Excludes Rs. 3,084 on account of pay, etc., of establishment employed on ½-inch mapping in No. 1 Party.
N	No. 20	Meerut, Dehra Dūn, Sahāranpur Remount Depôt, Hāpur (Bābūgarh) Remount Depôt, Santa Cruz, Kālka, Peshāwar, Bannu, Jullundur, Landour, Sanāwar, and Bakloh.	...	...	...	...	...	...	...	...	...	1·07†	11·52†	0·01†	0·64†	...	0·50†	30·59	45,901	†Per acre.
N	Simla Survey Detachment.	Simla	...	...	...	...	...	Special Simla Survey.			...	...	...	...	...	...	...	acres. 9,336	35,903	

TABLE III—*concluded.*

COST-RATES OF SURVEY—*concluded.*

Circle.	Party.	Locality.	COST-RATE, RUPEES, PER SQUARE MILE.												COST-RATE, RUPEES.			Total survey outturns on all scales square miles.	Total cost of party.	REMARKS.
															TRAVERSING PER LINEAR MILE.					
			¼-inch survey.	½-inch survey.	1-inch survey.	1-inch revision survey.	1-inch re-survey.	1-inch supplementary survey.	1½-inch survey.	2-inch survey.	4-inch survey.	16-inch survey.	64-inch survey.	Triangulation.	Topographical.	Forest survey.	Fair mapping per square mile.		Rs.	
S	No. 5	Central Provinces, Berār, Bombay and Central India.	...	...	11·1	7·0	...	...	...	25·9	...	...	...	6·1	24·2	...	3·0	4,435	79,761	
S	No. 6	Berār, Bombay and Hyderābād	...	5·3	10·6	9·7	...	...	...	20·0	...	...	...	3·1	...	...	2·3	7,640	95,885	
S	No. 7	Madras, Mysore and Pondicherry.	...	...	9·5	9·0	...	6·0	...	30·9	...	...	...	7·0	...	...	4·5	5,423	88,193	
S	No. 8	Madras	...	...	39·3	...	...	...	34·5	...	...	...	...	10·8	24·8	...	19·2	1,788	1,11,521	
E	No. 9	Bengal	...	...	...	...	...	...	...	...	...	...	...	...	13·9	...	22·6(*d*) 3·2(*e*)		80,692	(*d*) For 1-inch. (*e*) For ½-inch.
E	No. 10	Upper Burma . . .	...	...	33·5	8·17	...	...	...	83·6	...	...	...	7·07	...	78·7	6·9	2,068	1,37,581(*f*)	(*f*) Exclusive of Maymyo Drawing Office Rs. 2,577, and instruction camp Rs. 14,802.
E	No. 11	Ditto	...	...	...	16·4	...	...	...	...	...	...	...	4·7	...	49·1	2·5(*g*) 1·4(*h*)	315	71,624	(*g*) For ½-inch. (*h*) For ¼-inch.
E	No. 12	Assam	...	...	28·2	...	...	19·6	...	65·9 61·1*	284·1*	...	...	12·2	27·9	...	8·6	2,448	1,40,231(*i*)	(*i*) Includes Rs. 10,093 expenditure on Special Forest Survey debitable to Forest Department.
E	Andamans Detachment.	Andaman Islands . . .	...	...	...	...	...	...	...	225(*j*)	...	...	...	...	51·9	...	*Nil*(*k*)	225	20,927(*l*)	(*j*) Skeleton survey (uncontoured). (*k*) Mapping in Forest Map Office, Dehra Dūn. (*l*) Debitable to Forest Department.

* Special Forest Survey.



The Comparator House, Dehra Dun.

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1916.

PART II.—GEODETIC AND SCIENTIFIC OPERATIONS.

ASTRONOMICAL LATITUDES.

No. 13 PARTY.

PERSONNEL.

Imperial Officers.

Captain V. R. Cotter, I.A., in charge, to 26th November 1914.

From 27th November 1914 the Superintendent of the Trigonometrical Survey held charge in addition to his other duties.

Lower Subordinate Service.

3 Computers, etc.

As no officer was available no latitude operations were undertaken, and the *personnel* of the party was employed at the Head-quarters offices.

PENDULUM OPERATIONS.

No. 14 PARTY.

PERSONNEL.

Imperial Officers.

Major A. A. McHarg, R.E., in charge to 6th October 1914.

Captain G. F. T. Oakes, R.E., attached from 1st to 6th October, in charge 7th to 20th October 1914.

Charge held by the Superintendent of the Trigonometrical Survey from 21st October to 2nd November 1914.

Major H. M. Cowie, R.E., in charge, 3rd to 16th November 1914.

From 17th November 1914 to 10th September 1915, charge was held by the Officer in charge No. 15 Party, and from 11th to 30th September 1915 by the Superintendent of the Trigonometrical Survey in addition to their other duties.

Upper Subordinate Service.

Mr. S. C. Mukharji.

Lower Subordinate Service.

3 Computers and 1 Traverser.

As no officer was available no pendulum work was undertaken. A detachment made up in part from the *personnel* of the party took part in the revision of the boundary between Nepāl and Pīlībhīt district.

This work is described on page 173.

TRIANGULATION.

No. 15 PARTY.

(*Vide* Index Map No. 14.)

BY J. DE GRAAFF HUNTER, M.A.

During the cold weather of 1914-15 the field work was carried out at first by two detachments as follows :—

(1) Mr. L. Williams, *the Ashta Series* and afterwards, *the Middle Godāvari Series ;*

(2) Messrs. G. A. Norman, B. T. Wyatt and A. J. Moore, *the Cāchār Series, the Kohīmā Series.*

A third detachment with Mr. B. T. Wyatt in charge was formed at the end of December 1914, to commence the reconnaissance of the Chittagong Principal Series.

PERSONNEL.

Imperial Officers.

Major E. A. Tandy, R.E., in charge till 10th September 1915.
J. de Graaff Hunter, Esq., M.A., in charge from 11th September 1915.

Provincial Officers.

Mr. L. Williams.
„ G. A. Norman.
„ B. T. Wyatt.
„ A. J. Moore to 24th September 1915.

Lower Subordinate Service.

19 Computers, etc.

NOTE.—Mr. B. T. Wyatt was transferred to the Basrah Survey Party on 1st September 1915.

Particulars of triangulation outturn during the year.

	PRINCIPAL.	SECONDARY.			
	Chittagong Series.	Ashta Series.	Middle Godāvari Series.	Cāchār Series.	Kohīmā Series.
Number of stations observed at	...	9	18	12	8
„ „ „ newly selected and built	10 (built)	5	13	10	...
Length of triangulation completed in miles		39	137	55	67
„ „ „ remaining to be done		...	...	30	...
Area of triangulation in square miles		426	1990	747	576
Number of triangles observed		7	18	9	9
„ „ astronomical azimuths observed		...	...	...	...
Maximum triangular error	Not observed.	3″·30	3″·67	2″·83	3″·7
Average „ „		2″·18	1″·25	1″·53	1″·6
Mean closing error in latitude		0″·28	0″·07	No connexion.	0″·21
„ „ „ „ longitude		0″·25	0″·10		0″·21
„ „ „ height		2·1 ft.	1·8 ft.		7·7 ft.
„ „ „ „ azimuth		4″·08	1″·6		9″·6
„ „ „ „ log side, the unit being the seventh place of decimals		246	47		413
Theodolite used		T. and S. 8 inch. Micr. No. 1311.	T. and S. 8 inch. Micr. No. 1311.	T. and S. 12 inch. Micr. No. III.	T. Cooke & Sons. 8 inch. Micr. No. 10163.

Principal Triangulation.

The Chittagong Series.—The Sambalpur Principal Series having been completed last year it was decided to postpone further principal triangulation until after the war. It was found, however, that one officer would only be required for a short period to assist in the secondary series in Assam and accordingly Mr. Wyatt was directed at the end of December 1914 to undertake the reconnaissance and building of the Chittagong Series, a new principal series which is to connect the Burma Coast Series with the Manipur Meridional Series and which will form an important link in the Burma Triangulation.

This series was reconnoitred and built from a base on the Burma Coast Series about 30 miles east-north-east of Chittagong, along a line keeping near the main road to Lungleh in the Lushai Hills and thence due eastwards almost up to a base on the Manipur Meridional Series, east of Falam and Haka in the Chin Hills. The series has been very satisfactorily laid out and forms a connexion across about 115 miles of difficult country by means of five strong figures, all giving double values. The final connexion with the Manipur Meridional Series was not quite completed owing to unfavourable weather and it is probably that connexion will have to be made with the eastern side of the Manipur Meridional by means of an extra quadrilateral. This matter which will involve the building of one additional station can easily be settled when observing work is commenced from the Burma end.

The 10 new stations bringing the series to this incomplete junction have all been built and very full notes have been recorded for the assistance of the principal detachment which will ultimately undertake the observations of the series.

Owing to a number of the mark-stones of the Burma Coast Series having been destroyed, the whole hexagon of the Burma Coast Series at the western end of the work will probably have to be reobserved.

The series extends from the plain and undulating country in Chittagong through successive parallel ranges of hills in the Chittagong Hill Tracts, South Lushai Hills and the Chin Hills. These ranges, which have a general direction of north to south, are separated by narrow valleys and increase in elevation towards the east where several peaks exceed 7,000 and 8,000 feet. The country for the most part is covered with dense jungle. Mule transport would be most suitable for the country and could be arranged for in consultation with the Burma topographical parties.

Secondary Triangulation.

The Ashta Series.—Only 8 stations of this series remained to be observed at to effect a connexion with the Karāchi Longitudinal Series, the entire building and three-fourths of the observations having been completed during the previous season. The work was completed by the middle of December and a satisfactory connexion made,—*vide* table of outturn.

The detachment was then transferred to the Hyderābād State, Nizam's Dominions, to take up the observations of the stations of the Middle Godāvari Series which had been laid out and built in season 1911-12 under the name of the Bhīr Series. The series connects the Great Arc and the Jabalpur Meridional Series and consists of 18 stations lying along the line of the Godāvari river. The observations were completed by about the middle of March and the

connexion proved very satisfactory. About 30 intersected points were fixed for the use of topographical parties.

The Cāchār Series.—This series connecting the Assam Valley Series and the Cāchār Branch of the Eastern Frontier Series was undertaken with a view to clearing up the doubts raised by the large closing differences of the Nāgā Hills Series completed during the previous season.

The reconnaissance and building of the series, which consists of 15 stations, was taken up early in November by Messrs. Norman and Wyatt and completed by the end of December. The former then took up the observations but was much delayed by unfavourable weather conditions and the great length of some of the sides. The final connexion with the Assam Valley Series was not completed and three stations remain to be observed at to complete the connexion. The country worked over was of a difficult nature and clad with dense jungle. Coolies and supplies were scarce and communications difficult.

The Kohīmā Series.—This series, which forms a connexion between the Nāgā Hills and the Cāchār and Jaintiā Hills Series and is a continuation of the last-named series, was taken up last year during which the series was laid out and the first 6 stations observed. Mr. Moore was directed to carry on the observations and establish the connexion. On accomplishing this, he went to Mr. Norman's assistance on the Cāchār Series, but the season was far advanced and haze and unfavourable weather rendered further progress impossible. The detachment was finally recalled without being able to complete the Cāchār Series.

TIDAL OPERATIONS.

No. 16 PARTY.

(*Vide* Index Map No. 14.)

BY MR. SYED AULAD HOSSEIN, K.B.

PERSONNEL.

Provincial Officers.

Mr. Syed Aulad Hossein, K.B., in charge till 13th December 1914 and again from 1st March 1915 to end of the year.

Mr. Syed Zille Hasnain, in charge from 14th December 1914 to 28th February 1915.

Mr. D. H. Luxa, from 22nd December 1914 to 28th February 1915.

Lower Subordinate Service.

1 Clerk.
15 Computers.
2 Tidal Observatory clerks.
2 Artificers.

During the year under report, registrations of the tides by self-registering tide-gauges were carried out at the ports of Aden, Karāchi, Apollo Bandar (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein, and Port Blair.

These operations were conducted under the direction of this Department: the immediate control of all the tidal observatories being entrusted to the local officers of the ports concerned.

In addition to the above work, the predictions of high and low water for 1914 at Bhaunagar, Akyab and Chittagong, where regular tidal registrations by self-registering tide-gauges were discontinued some years ago, were compared against actual readings of high and low water supplied by the Port Officers concerned. These readings were taken during daylight on tide-poles at Bhaunagar and Akyab throughout the year and at Chittagong from June to December 1914. From 1st January to end of May 1914 the actual record of high and low water at Chittagong was obtained from the diagrams of a small self-registering river-gauge supplied by the Port Officer. It was subsequently found that the record of these diagrams was not wholly satisfactory, and hence they were discontinued after May 1914. The object of the above comparisons was to see whether the predictions which were based on observations taken some years ago still maintained the required degree of accuracy.

LIST OF TIDAL STATIONS.

The following is a complete list of the ports at which tidal observations have been carried out from the commencement of the tidal operations in 1874 up to the present time. The permanent stations are shown in italics; the others are minor stations which were closed on the completion of the requisite registrations.

Serial No.	STATIONS.	Automatic or personal observations.	Date of commencement of observations.	Date of closing of observations.	Number of years of observations.	REMARKS.
1	Suez . . .	Automatic	1897	1903	7	
2	Perim . . .	Ditto	1898	1902	5	
3	*Aden* . . .	Ditto	1879	Still working	36	
4	Maskat . . .	Ditto	1893	1898	6	
5	Bushire . . .	Ditto	1892	1901	8	
6	*Karāchi* . .	Ditto	1868 1881	1880 Still working	*13 35 } 48	* Small tide-gauge working.
7	Hanstal . . .	Ditto	1874	1875	1	Tide-tables not published.

Serial No.	STATIONS.	Automatic or personal observations.	Date of commencement of observations.	Date of closing of observations.	Number of years of observations.	REMARKS.
8	Navānar	Automatic	1874	1875	1	Tide-tables not published.
9	Okha Point	Ditto	1874 Restarted 1904	1875 1906	1 1 } 2	Year 1904-05 is excluded.
10	Porbandar	Personal	1893	1894	2	
10A	Porbandar	Automatic	1898	1902	2	Years 1898, 1899 and 1902 are excluded.
11	Port Albert Victor (Kāthiāwār).	Personal	1881	1882	1	
11A	Port Albert Victor (Kāthiāwār).	Automatic	1900	1903	4	
12	Bhaunagar	Ditto	1889	1894	5	
13	*Bombay (Apollo Bandar).*	Ditto	1878	Still working	37	
14	*Bombay (Prince's Dock).*	Ditto	1888	Ditto	27	
15	Marmagao (Goa)	Ditto	1884	1889	5	
16	Kārwār	Ditto	1878	1883	5	
17	Beypore	Ditto	1878	1884	6	
18	Cochin	Ditto	1886	1892	6	
19	Tuticorin	Ditto	1888	1893	5	
20	Minicoy	Ditto	1891	1896	5	
21	Galle	Ditto	1884	1890	6	
22	Colombo	Ditto	1884	1890	6	
23	Trincomalee	Ditto	1890	1896	6	
24	Pāmban Pass	Ditto	1878	1882	4	
25	Negapatam	Ditto	1881	1888	5	Years 1883 to 1885 are excluded.
26	*Madras*	Ditto	1880 Restarted 1895	1890 Still working	10 20 } 30	
27	Cocanāda	Ditto	1886	1891	5	
28	Vizagapatam	Ditto	1879	1885	6	
29	False Point	Ditto	1881	1885	4	
30	Dublat (Sāgar Island)	Ditto	1881	1886	5	
31	Diamond Harbour	Ditto	1881	1886	5	
32	*Kidderpore*	Ditto	1881	Still working	34	
33	Chittagong	Ditto	1886	1891	5	
34	Akyab	Ditto	1887	1892	5	
35	Diamond Island	Ditto	1895	1899	5	
36	Bassein (Burma)	Ditto	1902	1903	2	
37	Elephant Point	Ditto	1880 Restarted 1884	1881 1888	} 5	Year 1880-81 is excluded.
38	*Rangoon*	Ditto	1880	Still working	35	
39	Amherst	Ditto	1880	1886	6	
40	*Moulmein*	Ditto	1880 Restarted 1909	1886 Still working	6 6 } 12	
41	Mergui	Ditto	1889	1894	5	
42	*Port Blair*	Ditto	1880	Still working	35	

WORKING OF THE OBSERVATORIES.

The inspection of the tidal observatories at Bombay (Apollo Bandar and Prince's Dock), Madras, Kidderpore, Rangoon, Moulmein and Port Blair was carried out by Mr. Syed Zille Hasnain. Mr. Luxa who was temporarily posted to this party, during Mr. Syed Aulad Hossein's absence on leave, went through the various details of the inspection at the two observatories at Bombay with Mr. Syed Zille Hasnain. Subsequently he inspected the tidal observatories at Aden and Karāchi by himself.

During the inspection of each observatory all the instruments were thoroughly overhauled, cleaned and put in working order. The relative levels of the bed-plate of the tide-gauge and the bench-mark of reference were tested by means of spirit levelling operations and the working zero of the tide-gauge was compared with the true or adopted zero. All the other details of the inspection including the examination of the observatory cabin and the communication between the sea and the observatory well were minutely gone through and the instruments were left in perfect adjustment and working order.

The following remarks regarding the working of each observatory may be added:—

Aden.—During the past year there were 12 interruptions of a few hours each in the registrations of the tide-gauge chiefly owing to the stoppage of the driving clock. Most of these interruptions occurred during the rainy season when the sea was generally rough.

Karāchi.—The tide-gauge at this observatory worked well throughout the year. The communication between the sea and the observatory well was partially blocked for short intervals more than once, the cause apparently being some obstacle, like a shell-fish, temporarily sticking in the inlet hole and then passing out by itself.

Bombay (Apollo Bandar).—There have been no interruptions in the registrations of the tide-gauge, and the whole work connected with this observatory has been satisfactorily carried out.

Bombay (Prince's Dock).—Since the last report on this observatory, the working of the tide-gauge showed considerable improvement in the earlier part of the year, but later on the tidal registrations began to be interrupted owing to the stoppage of the driving clock or the breaking of the pencil wire. During July and August last such interruptions were unusually frequent. The matter was brought to the notice of the Chief Engineer of the port who had the tide-gauge and the driving clock examined by one of his own mechanics. Since then no further breaks in the registrations of the tide-gauge have occurred.

Madras.—The tide-gauge at this observatory has worked most satisfactorily during the year under report.

Kidderpore.—The tidal registrations at this observatory have been continuous and satisfactory. In the course of the last annual inspection of the observatory it was found that there was nearly four inches of mud inside the float cylinder and that the periodical cleaning of the mud by means of a fire-engine from the vicinity of the observatory was not satisfactorily carried out. All that the engine appeared to have done was to clear a path on the north side of the observatory for the passage of the water to the cylinder, but mud was allowed to accumulate round the cylinder on the other sides. The matter was at once reported to the Deputy Conservator of the Port who was requested to

have dredging operations carried out all round the observatory to ensure that there was always two or three feet of water below the bottom of the cylinder. Unless this was done at short intervals there was a danger of the communication between the river and the cylinder being blocked or at least retarded at any time.

Rangoon.—The Inspecting Officer noticed last year that the bottom piece of the iron cylinder of this observatory was showing signs of wear and tear and that the silt in the river was frequently collecting round the bottom of the cylinder and partially blocking the inlet holes. It was, therefore, decided to have the bottom piece of the cylinder renewed and, at the same time, to have the total length of the cylinder reduced to a certain extent, in order to have as much clearance as possible between the bottom of the cylinder and the river-bed. The length of the cylinder could be safely reduced by four feet from the bottom, after allowing for a sufficient play for the float at the lowest low tide. The Deputy Conservator of the Port was accordingly requested to have a new bottom-piece of the cylinder prepared four feet shorter than the old piece which was nearly eight feet in length. On arrival at Rangoon in February 1915 the Inspecting Officer found that the new piece of the cylinder was ready. He had the old piece removed and the new piece fixed in its place. The reduction in the length of the cylinder has had the desired effect, as since then no complaints have reached this office of the silt in the river coming up to the bottom of the cylinder and interfering with the communication between the river and the tide-gauge which has worked smoothly.

Moulmein.—With the exception of a few minor interruptions in the registrations due to the stoppage of the driving clock, the tide-gauge has worked well during the year.

Port Blair.—During the year 1914 the Chief Commissioner of Port Blair wrote to the Superintendent of the Trigonometrical Survey that it was desirable for local requirements to shift the tidal observatory to a new site about 90 feet towards the south. This site had already been inspected and approved of by the Inspecting Officer when he visited Port Blair in January 1914. The Superintendent of the Trigonometrical Survey having consented to the above proposal, the building of the new observatory was taken in hand by the Chief Commissioner and was finished by the end of February 1915, when the Inspecting Officer next visited Port Blair. On 1st March 1915 the tide-gauge and other instruments were removed from the old to the new observatory where tidal registrations have been carried out most satisfactorily up to the present time.

The new observatory is made of reinforced cement with wooden flooring and roof and is in every way much better than the old building.

COMPUTATIONS AND REDUCTION OF OBSERVATIONS.

All the computations pertaining to past year's work have been completed and there are no arrears. The tidal observations at the nine working stations for the year 1914 have been reduced by harmonic analysis and the values for the tidal constants thus determined are shown in the attached tables.

These tables give the amplitudes (R) and the epochs (ζ) at the various stations; they also give the values of H and K which are connected with R and ζ in such a way, through the various astronomical quantities involved in the position of the sun and moon, that if the tidal observations were consistent from year to year H and K would come out the same from each year's reductions.

ADEN, 1914.

Short Period Tides.

$A_0 = 5{\cdot}833$ feet.

	$H = R =$	$\kappa = \zeta =$
S_1	·107	168°·82
S_2	·661	244°·73
S_4	·010	274°·00
S_6	·006	208°·44
S_8	·002	352°·57

	$R =$	$\zeta =$	$H =$	$\kappa =$
M_1	·061	47°·55	·028	100°·20
M_2	1·495	331°·83	1·548	227°·18
M_3	·016	4°·70	·017	207°·73
M_4	·012	166°·85	·012	317°·55
M_6	·008	282°·10	·009	328°·15
M_8	·002	104°·04	·002	45°·44
O_1	·765	336°·63	6·52	37°·87
K_1	1·435	201°·58	1·296	34°·54
K_2	·233	34°·15	·180	240°·39
P_1	·416	222°·48	·416	32°·31
J_1	·072	50°·40	·063	33°·35
Q_1	·183	127°·55	·156	39°·95
L_2	·018	31°·19	·025	233°·45
N_2	·443	117°·66	·458	224°·16
λ_2	...	...	...	...
ν_2	·131	265°·84	·136	204°·61
μ_2	·088	35°·58	·095	186°·29
R_2	...	...	...	...
T_2	·060	280°·22	·060	281°·52
$(MS)_4$	·011	318°·23	·011	213°·58
$(2SM)_2$	·017	354°·90	·018	99°·55
$2N_2$	·082	224°·45	·085	182°·11
$(M_2N)_4$	·007	225°·59	·008	227°·45
$(M_2K_1)_3$	·021	69°·58	·019	157°·89
$(2M_2K_1)_3$	·007	84°·64	·006	42°·39

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·009	218°·27	·010	7°·11
„ Fortnightly „	·054	48°·66	·038	1°·52
Luni-Solar „ „	·010	192°·83	·010	297°·48
Solar-Annual „	·371	64°·39	·371	344°·56
„ Semi-Annual „	·171	266°·24	·171	106°·58

KARĀCHI, 1914.

Short Period Tides.

$A_0 = 7·318$ feet.

S_1	$H = R =$	·092	M_6	$R =$	·041	Q_1	$R =$	·183	T_2	$R =$	·109
	$\kappa = \zeta =$	191°·74		$\zeta =$	155°·51		$\zeta =$	137°·55		$\zeta =$	3°·03
S_2	$H = R =$	·971		$H =$	·046		$H =$	·156		$H =$	·109
	$\kappa = \zeta =$	323°·31		$\kappa =$	206°·03		$\kappa =$	52°·30		$\kappa =$	4°·38
S_4	$H = R =$	·011	M_8	$R =$	·002	L_2	$R =$	·051	$(MS)_4$	$R =$	·041
	$\kappa = \zeta =$	349°·51		$\zeta =$	335°·56		$\zeta =$	91°·24		$\zeta =$	57°·12
S_6	$H = R =$	·010		$H =$	·002		$H =$	·070		$H =$	·043
	$\kappa = \zeta =$	300°·26		$\kappa =$	282°·92		$\kappa =$	294°·20		$\kappa =$	313°·96
S_8	$H = R =$	·0003	O_1	$R =$	·786	N_2	$R =$	·630	$(2SM)_2$	$R =$	·014
	$\kappa = \zeta =$	315°·00		$\zeta =$	344°·27		$\zeta =$	170°·29		$\zeta =$	353°·93
				$H =$	·670		$H =$	·653		$H =$	·015
				$\kappa =$	47°·06		$\kappa =$	279°·08		$\kappa =$	97°·09
M_1	$R =$	·058	K_1	$R =$	1·465	λ_2	$R =$	...	$2N_2$	$R =$	·076
	$\zeta =$	48°·50		$\zeta =$	212°·67		$\zeta =$	...		$\zeta =$	276°·96
	$H =$	·027		$H =$	1·324		$H =$	...		$H =$	·079
	$\kappa =$	101°·89		$\kappa =$	45°·57		$\kappa =$	...		$\kappa =$	237°·70
M_2	$R =$	2·508	K_2	$R =$	·345	ν_2	$R =$	·195	$(M_2N)_4$	$R =$	·019
	$\zeta =$	36°·62		$\zeta =$	112°·93		$\zeta =$	321°·60		$\zeta =$	345°·51
	$H =$	2·597		$H =$	·266		$H =$	·202		$H =$	·021
	$\kappa =$	293°·46		$\kappa =$	319°·05		$\kappa =$	262°·55		$\kappa =$	351°·14
M_3	$R =$	·045	P_1	$R =$	·414	μ_2	$R =$	·083	$(M_2K_1)_3$	$R =$	·002
	$\zeta =$	114°·19		$\zeta =$	234°·64		$\zeta =$	102°·54		$\zeta =$	278°·53
	$H =$	·048		$H =$	·414		$H =$	·089		$H =$	·002
	$\kappa =$	319°·45		$\kappa =$	44°·53		$\kappa =$	256°·22		$\kappa =$	8°·27
M_4	$R =$	·014	J_1	$R =$	·064	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·013
	$\zeta =$	177°·83		$\zeta =$	62°·47		$\zeta =$	...		$\zeta =$	26°·77
	$H =$	·015		$H =$	·055		$H =$	...		$H =$	·013
	$\kappa =$	331°·51		$\kappa =$	44°·57		$\kappa =$	...		$\kappa =$	347°·55

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·039	168°·29	·044	316°·34
„ Fortnightly „	·047	97°·76	·033	49°·01
Luni-Solar „ „	·030	233°·96	·031	337°·12
Solar-Annual „	·155	224°·69	·155	144°·80
„ Semi-Annual „	·195	299°·74	·195	139°·96

BOMBAY (APOLLO BANDAR), 1914.

Short Period Tides.

$A_0 = 10{\cdot}257$ feet.

S_1	$H = R =$	·079	M_6	$R =$	·012	Q_1	$R =$	·177	T_2	$R =$	·198
	$\kappa = \zeta =$	193°·53		$\zeta =$	348°·91		$\zeta =$	140°·49		$\zeta =$	36°·58
S_2	$H = R =$	1·554		$H =$	·013		$H =$	·150		$H =$	·198
	$\kappa = \zeta =$	5°·24		$\kappa =$	40°·62		$\kappa =$	55°·86		$\kappa =$	37°·96
S_4	$H = R =$	·019	M_8	$R =$	·010	L_2	$R =$	·039	$(MS)_4$	$R =$	·089
	$\kappa = \zeta =$	245°·48		$\zeta =$	68°·58		$\zeta =$	52°·44		$\zeta =$	132°·58
S_6	$H = R =$	·005		$H =$	·012		$H =$	·053		$H =$	·093
	$\kappa = \zeta =$	147°·34		$\kappa =$	17°·53		$\kappa =$	255°·58		$\kappa =$	29°·82
S_8	$H = R =$	·003	O_1	$R =$	·755	N_2	$R =$	·977	$(2SM)_2$	$R =$	·037
	$\kappa = \zeta =$	187°·35		$\zeta =$	345°·60		$\zeta =$	209°·13		$\zeta =$	18°·94
				$H =$	·643		$H =$	1·011		$H =$	·038
				$\kappa =$	48°·81		$\kappa =$	318°·53		$\kappa =$	121°·70
M_1	$R =$	·077	K_1	$R =$	1·531	λ_2	$R =$	...	$2N_2$	$R =$	·135
	$\zeta =$	43°·90		$\zeta =$	212°·59		$\zeta =$	...		$\zeta =$	338°·29
	$H =$	·036		$H =$	1·383		$H =$	...		$H =$	·140
	$\kappa =$	97°·48		$\kappa =$	45°·47		$\kappa =$	...		$\kappa =$	299°·85
M_2	$R =$	3·816	K_2	$R =$	·527	ν_2	$R =$	·297	$(M_2N)_4$	$R =$	·008
	$\zeta =$	74°·20		$\zeta =$	155°·22		$\zeta =$	356°·55		$\zeta =$	244°·47
	$H =$	3·951		$H =$	·407		$H =$	·308		$H =$	·008
	$\kappa =$	331°·43		$\kappa =$	1°·31		$\kappa =$	298°·08		$\kappa =$	251°·11
M_3	$R =$	·060	P_1	$R =$	·411	μ_2	$R =$	·240	$(M_2K_1)_3$	$R =$	·076
	$\zeta =$	191°·97		$\zeta =$	233°·26		$\zeta =$	146°·57		$\zeta =$	133°·08
	$H =$	·063		$H =$	·411		$H =$	·257		$H =$	·071
	$\kappa =$	37°·82		$\kappa =$	43°·17		$\kappa =$	301°·04		$\kappa =$	223°·19
M_4	$R =$	·082	J_1	$R =$	·062	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·044
	$\zeta =$	156°·05		$\zeta =$	75°·08		$\zeta =$	...		$\zeta =$	98°·56
	$H =$	·088		$H =$	·053		$H =$	...		$H =$	·043
	$\kappa =$	310°·52		$\kappa =$	56°·95		$\kappa =$	...		$\kappa =$	60°·16

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·063	160°·91	·072	308°·75
„ Fortnightly „	·081	66°·18	·057	17°·00
Luni-Solar „ „	·045	200°·72	·047	303°·49
Solar-Annual „	·105	292°·38	·105	212°·47
„ Semi-Annual „	·152	315°·68	·152	155°·87

BOMBAY (PRINCE'S DOCK), 1914.

Short Period Tides.

A_0=8·318 feet.

S_1	H = R =	·102	M_6	R =	·011	Q_1	R =	·183	T_2	R =	·204
	κ = ζ =	186°·27		ζ =	135°·80		ζ =	140°·01		ζ =	33°·80
S_2	H = R =	1·618		H =	·013		H =	·156		H =	·204
	κ = ζ =	4°·22		κ =	187°·52		κ =	55°·38		κ =	35°·17
S_4	H = R =	·021	M_8	R =	·006	L_2	R =	·031	$(MS)_4$	R =	·129
	κ = ζ =	214°·59		ζ =	91°·19		ζ =	89°·08		ζ =	147°·25
S_6	H = R =	·005		H =	·007		H =	·043		H =	·133
	κ = ζ =	167°·99		κ =	40°·15		κ =	292°·22		κ =	44°·49
			O_1	R =	·762	N_2	R =	1·003	$(2SM)_2$	R =	·046
S_8	H = R =	·002		ζ =	344°·81		ζ =	206°·56		ζ =	2°·76
	κ = ζ =	158°·20		H =	·649		H =	1·039		H =	·048
				κ =	48°·02		κ =	315°·96		κ =	105°·52
M_1	R =	·075	K_1	R =	1·549	λ_2	R =	...	$2N_2$	R =	·137
	ζ =	42°·68		ζ =	212°·04		ζ =	...		ζ =	338°·29
	H =	·035		H =	1·399		H =	...		H =	·141
	κ =	96°·27		κ =	44°·91		κ =	...		κ =	299°·85
M_2	R =	3·931	K_2	R =	·535	ν_2	R =	·279	$(M_2N)_4$	R =	·012
	ζ =	73°·47		ζ =	152°·33		ζ =	351·58		ζ =	32°·32
	H =	4·070		H =	·413		H =	·289		H =	·013
	κ =	330°·71		κ =	358°·42		κ =	293°·12		κ =	38°·96
M_3	R =	·065	P_1	R =	·410	μ_2	R =	·226	$(M_2K_1)_3$	R =	·074
	ζ =	192°·43		ζ =	234°·66		ζ =	146°·90		ζ =	118°·95
	H =	·068		H =	·410		H =	·242		H =	·069
	κ =	38°·29		κ =	44°·56		κ =	301°·38		κ =	209°·07
M_4	R =	·094	J_1	R =	·065	R_2	R =	...	$(2M_2K_1)_3$	R =	·053
	ζ =	184°·90		ζ =	72°·21		ζ =	...		ζ =	116°·06
	H =	·101		H =	·056		H =	...		H =	·051
	κ =	339°·38		κ =	54°·07		κ =	...		κ =	77°·67

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·077	168°·99	·088	316°·83
„ Fortnightly „ . . .	·100	64°·50	·070	15°·32
Luni-Solar „ „ . . .	·062	222°·81	·064	325°·57
Solar-Annual „ . .	·117	298°·57	·117	218°·67
„ Semi-Annual „ . . .	·149	316°·76	·149	156°·95

MADRAS, 1914.

Short Period Tides.

$A_0 = 2{\cdot}213$ feet.

S_1	H = R =	·038	M_6	R =	·003	Q_1	R =	·013	T_2	R =	·007
	κ = ζ =	82°·67		ζ =	36°·87		ζ =	182°·60		ζ =	262°·46
S_2	H = R =	·445		H =	·004		H =	·011		H =	·007
	κ = ζ =	273°·84		κ =	90°·10		κ =	98°·77		κ =	263°·85
S_4	H = R =	·001	M_8	R =	·002	L_2	R =	·012	$(MS)_4$	R =	·005
	κ = ζ =	141°·34		ζ =	184°·40		ζ =	30°·16		ζ =	63°·44
S_6	H = R =	·001		H =	·002		H =	·017		H =	·006
	κ = ζ =	55°·01		κ =	135°·37		κ =	233°·53		κ =	321°·18
S_8	H = R =	·001	O_1	R =	·107	N_2	R =	·229	$(2SM)_2$	R =	·019
	κ = ζ =	168°·69		ζ =	264°·22		ζ =	127°·67		ζ =	125°·32
				H =	·092		H =	·238		H =	·019
				κ =	327°·95		κ =	237°·85		κ =	227°·58
M_1	R =	·020	K_1	R =	·326	λ_2	R =	...	$2N_2$	R =	·052
	ζ =	315°·00		ζ =	145°·27		ζ =	...		ζ =	243°·44
	H =	·009		H =	·294		H =	...		H =	·054
	κ =	8°·84		κ =	338°·13		κ =	...		κ =	206°·04
M_2	R =	1·032	K_2	R =	·172	ν_2	R =	·088	$(M_2N)_4$	R =	·006
	ζ =	344°·73		ζ =	69°·65		ζ =	281°·88		ζ =	140°·86
	H =	1·068		H =	·133		H =	·091		H =	·006
	κ =	242°·47		κ =	275°·69		κ =	224°·15		κ =	148°·77
M_3	R =	·004	P_1	R =	·110	μ_2	R =	·045	$(M_2K_1)_3$	R =	·010
	ζ =	160°·64		ζ =	172°·43		ζ =	32°·54		ζ =	83°·99
	H =	·004		H =	·110		H =	·048		H =	·009
	κ =	7°·25		κ =	342°·36		κ =	188°·03		κ =	174°·59
M_4	R =	·007	J_1	R =	·028	R_2	R =	...	$(2M_2K_1)_3$	R =	·005
	ζ =	52°·05		ζ =	336°·97		ζ =	...		ζ =	335°·77
	H =	·007		H =	·024		H =	...		H =	·004
	κ =	207°·53		κ =	318°·54		κ =	...		κ =	298°·40

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·023	317°·68	·026	105°·25
,, Fortnightly ,, ...	·056	83°·87	·039	34°·14
Luni-Solar ,, ,, ...	·023	184°·25	·024	286°·51
Solar-Annual ,, . .	·364	301°·76	·364	221°·83
,, Semi-Annual ,, . . .	·373	297°·03	·373	137°·17

KIDDERPORE, 1914.

Short Period Tides.

$A_0 = 10·313$ feet.

S_1	$H = R =$	·087
	$\kappa = \zeta =$	201°·68
S_2	$H = R =$	1·587
	$\kappa = \zeta =$	97°·88
S_4	$H = R =$	·109
	$\kappa = \zeta =$	109°·16
S_6	$H = R =$	·006
	$\kappa = \zeta =$	38°·21
S_8	$H = R =$	·006
	$\kappa = \zeta =$	315°·00
M_1	$R =$	·047
	$\zeta =$	26°·84
	$H =$	·022
	$\kappa =$	80°·95
M_2	$R =$	3·720
	$\zeta =$	156°·44
	$H =$	3·852
	$\kappa =$	54°·72
M_3	$R =$	·059
	$\zeta =$	93°·40
	$H =$	·062
	$\kappa =$	300°·83
M_4	$R =$	·720
	$\zeta =$	233°·28
	$H =$	·772
	$\kappa =$	29°·85
M_6	$R =$	·149
	$\zeta =$	257°·58
	$H =$	·165
	$\kappa =$	312°·44
M_8	$R =$	·068
	$\zeta =$	311°·51
	$H =$	·078
	$\kappa =$	264°·66
O_1	$R =$	·245
	$\zeta =$	321°·45
	$H =$	·209
	$\kappa =$	25°·75
K_1	$R =$	·461
	$\zeta =$	218°·58
	$H =$	·417
	$\kappa =$	51°·42
K_2	$R =$	·570
	$\zeta =$	249°·16
	$H =$	·440
	$\kappa =$	95°·16
P_1	$R =$	·154
	$\zeta =$	236°·50
	$H =$	·154
	$\kappa =$	46°·45
J_1	$R =$	·036
	$\zeta =$	25°·29
	$H =$	·031
	$\kappa =$	6°·55
Q_1	$R =$	·020
	$\zeta =$	62°·00
	$H =$	·017
	$\kappa =$	339°·02
L_2	$R =$	·194
	$\zeta =$	191°·37
	$H =$	·265
	$\kappa =$	35°·00
N_2	$R =$	·754
	$\zeta =$	290°·33
	$H =$	·781
	$\kappa =$	41°·35
λ_2	$R =$	...
	$\zeta =$	...
	$H =$	...
	$\kappa =$	...
ν_2	$R =$	·325
	$\zeta =$	76°·31
	$H =$	·336
	$\kappa =$	19°·37
μ_2	$R =$	·289
	$\zeta =$	26°·80
	$H =$	·310
	$\kappa =$	183°·37
R_2	$R =$	...
	$\zeta =$	...
	$H =$	...
	$\kappa =$	...
T_2	$R =$	·219
	$\zeta =$	158°·94
	$H =$	·219
	$\kappa =$	160°·35
$(MS)_4$	$R =$	·703
	$\zeta =$	173°·69
	$H =$	·728
	$\kappa =$	71°·98
$(2SM)_2$	$R =$	·073
	$\zeta =$	269°·84
	$H =$	·076
	$\kappa =$	11°·56
$2N_2$	$R =$	·077
	$\zeta =$	324°·35
	$H =$	·080
	$\kappa =$	288°·09
$(M_2N)_4$	$R =$	·269
	$\zeta =$	9°·37
	$H =$	·289
	$\kappa =$	18°·67
$(M_2K_1)_3$	$R =$	·152
	$\zeta =$	281°·15
	$H =$	·143
	$\kappa =$	12°·27
$(2M_2K_1)_3$	$R =$	·030
	$\zeta =$	348°·23
	$H =$	·029
	$\kappa =$	311°·97

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·117	237°·14	·133	24°·42
" Fortnightly " . . .	·329	82°·54	·231	32°·23
Luni-Solar " " . . .	·941	302°·22	·975	43°·93
Solar-Annual " . . .	2·418	225°·47	2·418	145°·52
" Semi-Annual " . . .	·800	103°·21	·800	303°·31

RANGOON, 1914.

Short Period Tides.

$A_0 = 10{\cdot}208$ feet.

S_1	$H=R$ =	·149	M_6	R =	·228	Q_1	R =	·015	T_2	R =	·267
	$\kappa=\zeta$ =	127°·19		ζ =	25°·17		ζ =	154°·98		ζ =	190°·72
S_2	$H=R$ =	2·218		H =	·253		H =	·013		H =	·267
	$\kappa=\zeta$ =	167°·43		κ =	81°·62		κ =	72°·85		κ =	192°·16
S_4	$H=R$ =	·092	M_8	R =	·095	L_2	R =	·440	$(MS)_4$	R =	·506
	$\kappa=\zeta$ =	253°·00		ζ =	138°·09		ζ =	279°·37		ζ =	306°·41
S_6	$H=R$ =	·011		H =	·110		H =	·600		H =	·524
	$\kappa=\zeta$ =	33°·55		κ =	93°·36		κ =	123°·24		κ =	205°·22
S_8	$H=R$ =	·005	O_1	R =	·340	N_2	R =	1·089	$(2SM)_2$	R =	·194
	$\kappa=\zeta$ =	55°·38		ζ =	317°·75		ζ =	4°·68		ζ =	305°·39
				H =	·290		H =	1·128		H =	·200
				κ =	22°·61		κ =	116°·51		κ =	46°·57
M_1	R =	·072	K_1	R =	·759	λ_2	R =	...	$2N_2$	R =	·259
	ζ =	40°·22		ζ =	199°·99		ζ =	...		ζ =	51°·76
	H =	·034		H =	·686		H =	...		H =	·269
	κ =	94°·60		κ =	32°·81		κ =	...		κ =	16°·60
M_2	R =	5·780	K_2	R =	·809	ν_2	R =	·456	$(M_2N)_4$	R =	·191
	ζ =	230°·76		ζ =	321°·68		ζ =	161°·41		ζ =	145°·51
	H =	5·985		H =	·624		H =	·472		H =	·205
	κ =	129°·58		κ =	167°·64		κ =	105°·25		κ =	156°·15
M_3	R =	·056	P_1	R =	·197	μ_2	R =	·476	$(M_2K_1)_3$	R =	·196
	ζ =	134°·03		ζ =	245°·75		ζ =	136°·09		ζ =	324°·22
	H =	·059		H =	·197		H =	·510		H =	·183
	κ =	342°·26		κ =	55°·72		κ =	293°·73		κ =	55°·86
M_4	R =	·491	J_1	R =	·032	R_2	R =	...	$(2M_2K_1)_3$	R =	·119
	ζ =	6°·73		ζ =	114°·16		ζ =	...		ζ =	89°·85
	H =	·526		H =	·028		H =	...		H =	·115
	κ =	164°·36		κ =	95°·12		κ =	...		κ =	54°·67

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·210	233°·97	·239	20°·96
„ Fortnightly „	·219	99°·23	·154	48°·34
Luni-Solar „ „	·503	302°·28	·521	43°·46
Solar-Annual „	1·250	224°·08	1·250	144°·11
„ Semi-Annual „	·099	45°·95	·099	246°·00

MOULMEIN, 1914.

Short Period Tides.

A_0 = 8·392 feet.

S_1	H = R =	·114	M_6	R =	·065	Q_1	R =	·023	T_2	R =	·203
	κ = ζ =	135°·64		ζ =	119°·38		ζ =	150°·53		ζ =	158°·50
S_2	H = R =	1·511		H =	·072		H =	·020		H =	·203
	κ = ζ =	146°·06		κ =	176°·13		κ =	68°·55		κ =	159°·94
S_4	H = R =	·090	M_8	R =	·065	L_2	R =	·324	$(MS)_4$	R =	·769
	κ = ζ =	217°·06		ζ =	143°·45		ζ =	272°·36		ζ =	306°·31
S_6	H = R =	·011		H =	·074		H =	·442		H =	·796
	κ = ζ =	236°·45		κ =	99°·12		κ =	116°·28		κ =	205°·22
S_8	H = R =	·003	O_1	R =	·251	N_2	R =	·775	$(2SM)_2$	R =	·158
	κ = ζ =	291°·80		ζ =	336°·30		ζ =	345°·30		ζ =	302°·16
				H =	·214		H =	·803		H =	·164
				κ =	41°·26		κ =	97°·28		κ =	43°·25
M_1	R =	·054	K_1	R =	·531	λ_2	R =	...	$2N_2$	R =	·129
	ζ =	45°·30		ζ =	204°·38		ζ =	...		ζ =	22°·96
	H =	·025		H =	·480		H =	...		H =	·134
	κ =	99°·72		κ =	37°·19		κ =	...		κ =	348°·00
M_2	R =	4·000	K_2	R =	·491	ν_2	R =	·363	$(M_2N)_4$	R =	·319
	ζ =	212°·65		ζ =	305°·43		ζ =	153°·46		ζ =	141°·70
	H =	4·142		H =	·379		H =	·376		H =	·342
	κ =	111°·57		κ =	151°·39		κ =	97°·45		κ =	152°·59
M_3	R =	·062	P_1	R =	·152	μ_2	R =	·350	$(M_2K_1)_3$	R =	·202
	ζ =	145°·55		ζ =	254°·14		ζ =	125°·30		ζ =	345°·28
	H =	·066		H =	·152		H =	·375		H =	·189
	κ =	353°·92		κ =	64°·12		κ =	283°·13		κ =	77°·01
M_4	R =	·894	J_1	R =	·023	R_2	R =	...	$(2M_2K_1)_3$	R =	·111
	ζ =	5°·97		ζ =	89°·25		ζ =	...		ζ =	90°·11
	H =	·958		H =	·020		H =	...		H =	·108
	κ =	163°·80		κ =	70°·15		κ =	...		κ =	55°·13

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·413	240°·72	·470	27°·66
„ Fortnightly „	·455	96°·32	·319	45°·32
Luni-Solar „ „	1·163	301°·91	1·205	43°·00
Solar-Annual „	2·439	224°·28	2·439	144°·30
„ Semi-Annual „	·843	77°·01	·843	277°·06

PORT BLAIR, 1914.

Short Period Tides.

$A_0 = 4{\cdot}815$ feet.

S_1 H = R =	·021	M_6 R =	·002	Q_1 R =	·015	T_2 R =	·099
S_1 κ = ζ =	60°·15	M_6 ζ =	328°·39	Q_1 ζ =	295°·16	T_2 ζ =	343°·12
S_2 H = R =	·959	M_6 H =	·002	Q_1 H =	·012	T_2 H =	·099
S_2 κ = ζ =	312°·73	M_6 κ =	24°·15	Q_1 κ =	212°·66	T_2 κ =	344°·54
S_4 H = R =	·007	M_8 R =	·001	L_2 R =	·049	$(MS)_4$ R =	·015
S_4 κ = ζ =	200°·46	M_8 ζ =	168°·69	L_2 ζ =	39°·01	$(MS)_4$ ζ =	277°·80
S_6 H = R =	·001	M_8 H =	·001	L_2 H =	·066	$(MS)_4$ H =	·016
S_6 κ = ζ =	139°·40	M_8 κ =	123°·03	L_2 κ =	242°·77	$(MS)_4$ κ =	176°·39
S_8 H = R =	·002	O_1 R =	·181	N_2 R =	·404	$(2SM)_2$ R =	·020
S_8 κ = ζ =	317°·49	O_1 ζ =	237°·16	N_2 ζ =	160°·93	$(2SM)_2$ ζ =	58°·75
		O_1 H =	·154	N_2 H =	·418	$(2SM)_2$ H =	·021
		O_1 κ =	301°·78	N_2 κ =	272°·41	$(2SM)_2$ κ =	160°·16
M_1 R =	·030	K_1 R =	·445	λ_2 R =	...	$2N_2$ R =	·042
M_1 ζ =	306°·07	K_1 ζ =	132°·75	λ_2 ζ =	...	$2N_2$ ζ =	304°·84
M_1 H =	·014	K_1 H =	·402	λ_2 H =	...	$2N_2$ H =	·043
M_1 κ =	0°·33	K_1 κ =	325°·58	λ_2 κ =	...	$2N_2$ κ =	269°·20
M_2 R =	1·944	K_2 R =	·335	ν_2 R =	·127	$(M_2N)_4$ R =	·004
M_2 ζ =	19°·70	K_2 ζ =	103°·73	ν_2 ζ =	307°·97	$(M_2N)_4$ ζ =	88°·41
M_2 H =	2·013	K_2 H =	·258	ν_2 H =	·132	$(M_2N)_4$ H =	·004
M_2 κ =	278°·28	K_2 κ =	309°·71	ν_2 κ =	251°·48	$(M_2N)_4$ κ =	98°·47
M_3 R =	·006	P_1 R =	·132	μ_2 R =	·087	$(M_2K_1)_3$ R =	·020
M_3 ζ =	176°·93	P_1 ζ =	153°·71	μ_2 ζ =	127°·55	$(M_2K_1)_3$ ζ =	115°·54
M_3 H =	·006	P_1 H =	·132	μ_2 H =	·093	$(M_2K_1)_3$ H =	·019
M_3 κ =	24°·81	P_1 κ =	323°·67	μ_2 κ =	284°·72	$(M_2K_1)_3$ κ =	206°·95
M_4 R =	·019	J_1 R =	·029	R_2 R =	...	$(2M_2K_1)_3$ R =	·009
M_4 ζ =	311°·71	J_1 ζ =	326°·03	R_2 ζ =	...	$(2M_2K_1)_3$ ζ =	247°·95
M_4 H =	·021	J_1 H =	·025	R_2 H =	...	$(2M_2K_1)_3$ H =	·008
M_4 κ =	108°·88	J_1 κ =	307°·12	R_2 κ =	...	$(2M_2K_1)_3$ κ =	212°·30

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·035	274°·62	·040	61°·74
„ Fortnightly „	·040	59°·67	·028	9°·04
Luni-Solar „ „	·029	209°·50	·030	310°·92
Solar-Annual „	·247	229°·74	·247	149°·78
„ Semi-Annual „	·212	324°·56	·212	164°·64

DATA FORWARDED TO ENGLAND.

The following data were prepared and supplied to the Director, National Physical Laboratory, Teddington, England, during the year under report :—

(*a*) values of the tidal constants for 40 ports for the tide-tables for 1918 ready for use for the tide predicting machine;

(*b*) actual values of high and low water during 1913 at 12 stations. These include nine stations at which regular tidal observations by self-registering tide-gauges were carried out, two stations at which high and low water readings were taken during daylight on tide-poles, and one station at which times and heights of high and low water were obtained from the diagrams of a small river-gauge supplied by the Port Officer;

(*c*) comparisons of the above with predicted values for 1913: the errors being tabulated in such form as to be of use in improving the predictions.

ERRORS IN PREDICTIONS.

The predicted times and heights of high and low water for the year 1914 as given in the tide-tables, have been compared against the actual values obtained from tidal observations at the nine stations now working and at three other stations where tidal registrations by self-registering tide-gauges were stopped, but the times and heights of high and low water were read on the tide-poles.

The errors of the predictions thus determined are tabulated in the five tables herewith appended.

No. I.

Statement showing the percentage and the amount of the errors in the predicted times of high water at the various tidal stations for the year 1914.

Stations.	Automatic or tide-pole observations.	Number of comparisons between actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	673	29	39	11	13	8
Karāchi	Do.	702	40	38	9	9	4
Bhaunagar	T. P.	365	65	35	0	0	0
Bombay (Apollo Bandar)	Auto.	706	43	42	7	6	2
Bombay (Prince's Dock)	Do.	701	41	46	8	3	2
Madras	Do.	704	31	45	11	7	6
Kidderpore	Do.	705	32	40	14	10	4
Chittagong*	Auto and T. P.	486	27	32	9	14	18
Akyab	T. P.	361	99	1	0	0	0
Rangoon	Auto.	699	54	31	9	4	2
Moulmein	Do.	699	26	43	11	14	6
Port Blair	Do.	705	21	43	18	14	4

* Observations taken with a small river-gauge by the Port Officer for part of the year.

No. 2.

Statement showing the percentage and the amount of the errors in the predicted times of low water at the various tidal stations for the year 1914.

Stations.	Automatic or tide-pole observations.	Number of comparisons between actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	666	29	43	12	9	7
Karāchi	Do.	704	32	39	10	11	8
Bhaunagar	T. P.	365	68	32	0	0	0
Bombay (Apollo Bandar)	Auto.	705	38	46	8	6	2
Bombay (Prince's Dock)	Do.	695	37	49	10	3	1
Madras	Do.	705	43	37	6	7	7
Kidderpore	Do.	705	27	42	13	12	6
Chittagong*	Auto. and T. P.	479	21	35	14	14	16
Akyab	T. P.	357	98	2	0	0	0
Rangoon	Auto.	702	35	35	12	12	6
Moulmein	Do.	701	22	36	16	15	11
Port Blair	Do.	704	39	40	12	7	2

* Observations taken with a small river-gauge by the Port Officer for part of the year.

No. 3.

Statement showing the percentage and the amount of the errors in the predicted heights of high water at the various tidal stations for the year 1914.

Stations.	Automatic or tide-pole observations.	Number of comparisons between actual and predicted values.	Mean range at spring in feet.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
				Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	673	6·7	96	4	0	0
Karāchi	Do.	702	9·3	55	36	8	1
Bhaunagar	T. P.	365	31·4	61	34	5	0
Bombay (Apollo Bandar)	Auto.	706	13·9	71	24	4	1
Bombay (Prince's Dock)	Do.	701	13·9	66	26	6	2
Madras	Do.	704	3·5	88	10	2	0
Kidderpore	Do.	705	11·7	41	25	16	18
Chittagong*	Auto. and T. P.	486	13·3	47	25	17	11
Akyab	T. P.	361	8·3	88	11	1	0
Rangoon	Auto.	699	16·4	51	29	14	6
Moulmein	Do.	699	12·7	38	29	16	17
Port Blair	Do.	705	6·6	88	11	1	0

* Observations taken with a small river-gauge by the Port Officer for part of the year.

No. 4.

Statement showing the percentage and the amount of the errors in the predicted heights of low water at the various tidal stations for the year 1914.

Stations.	Automatic or tide-pole observations.	Number of comparisons between actual and predicted values.	Mean range at spring in feet.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
				Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	666	6·7	92	8	0	0
Karāchi	Do.	704	9·3	70	25	5	0
Bhaunagar	T. P.	365	31·4	60	35	5	0
Bombay (Apollo Bandar)	Auto.	705	13·9	66	26	7	1
Bombay (Prince's Dock)	Do.	695	13·9	66	27	6	1
Madras	Do.	705	3·5	85	14	1	0
Kidderpore	Do.	705	11·7	37	23	19	21
Chittagong*	Auto. and T. P.	479	13·3	49	25	14	12
Akyab	T. P.	357	8·3	84	13	1	2
Rangoon	Auto.	702	16·4	24	25	20	31
Moulmein	Do.	701	12·7	32	23	13	32
Port Blair	Do.	704	6·6	94	6	0	0

* Observations taken with a small river-gauge by the Port Officer for part of the year.

No. 5.

Table of average errors in the predicted times and heights of high and low water at the several tidal stations for the year 1914.

Stations.	Automatic or tide-pole observations.	Mean range at springs in feet.	Average errors. Of time in minutes.		Of height in terms of the range.		Of height in inches.	
			H. W.	L. W.	H. W.	L. W.	H. W.	L. W.
Open Coast.								
Aden	Auto.	6·7	13	13	·025	·025	2	2
Karāchi	Do.	9·3	10	13	·036	·027	4	3
Bhaunagar	T. P.	31·4	5	5	·011	·011	4	4
Bombay (Apollo Bandar)	Auto.	13·9	8	9	·018	·024	3	4
Bombay (Prince's Dock)	Do.	13·9	9	9	·024	·024	4	4
Madras	Do.	3·5	12	11	·048	·048	2	2
Akyab	T. P.	8·3	1	1	·020	·030	2	3
Port Blair	Auto.	6·6	13	9	·025	·025	2	2
General Mean	...	...	9	9	·026	·027	3	3
Riverain.								
Kidderpore	Auto.	11·7	12	13	·057	·057	8	8
Chittagong*	Auto. and T. P.	13·3	17	17	·038	·038	6	6
Rangoon	Auto.	16·4	8	12	·025	·051	5	10
Moulmein	Do.	12·7	13	15	·046	·066	7	10
General Mean	...	...	13	14	·042	·053	7	9

* Observations taken with a small river-gauge by the Port Officer for part of the year.

The foregoing statements for the year 1914 may be thus summarised :—

Percentage of time predictions within 15 minutes of actuals.

		High water.	Low water.
		Per cent.	Per cent.
Open coast stations.	6 at which predictions were tested by S. R. tide-gauge .	77	79
	2 ,, ,, ,, ,, tide-pole . .	100	100
Riverain stations.	3 ,, ,, ,, ,, S. R. tide-gauge .	75	66
	1 ,, ,, ,, ,, S. R. tide-gauge and tide-pole	60	56

Percentage of height predictions within 8 inches of actuals.

		High water.	Low water.
		Per cent.	Per cent.
Open coast stations.	6 at which predictions were tested by S. R. tide-gauge .	96	97
	2 ,, ,, ,, ,, tide-pole . .	97	96
Riverain stations.	3 ,, ,, ,, ,, S. R. tide-gauge .	71	55
	1 ,, ,, ,, ,, S. R. tide-gauge and tide-pole	72	74

Percentage of height predictions within one-tenth of mean range.

		High water.	Low water.
		Per cent.	Per cent.
Open coast stations.	6 at which predictions were tested by S. R. tide-gauge .	98	98
	2 ,, ,, ,, ,, tide-pole . .	100	99
Riverain stations.	3 ,, ,, ,, ,, S. R. tide-gauge .	92	84
	1 ,, ,, ,, ,, S. R. tide-gauge and tide-pole	95	95

COMPARISONS OF THE PREDICTIONS FOR 1914 WITH THOSE FOR THE PREVIOUS YEAR.

The predictions for heights of high and low water at all the working stations for the year 1914 have been just as good as those for the previous year. The predictions for times at Aden have become worse and at Moulmein slightly better than those for 1913 : at the remaining seven stations they are practically the same.

The greatest difference between the actual and predicted heights of low water for 1914 at the riverain ports were as follows :—

Kidderpore . .	3′ 3″	on 17th May 1914, actuals being higher.
Rangoon . .	2′ 5″	on 6th and 21st November 1914, actuals being lower.
Moulmein . .	3′ 0″	on 24th October 1914, actuals being lower.

TIDE-TABLES.

The tide-tables for the year 1916 have been received from England and distributed to the various officers concerned. The tide-tables for the year 1917 are being published in England and the data for the preparation of the tide-tables for 1918 were despatched to England in April 1915.

The amount realised on the sale of the tide-tables during the year ending September 1915 is Rs. 2,159.

PROGRAMME FOR SEASON 1915-16.

Tidal observations during the coming year will be continued at the 9 observatories now working.

LEVELLING.

No. 17 PARTY.

(*Vide* Index Map No. 14).

BY MR. H. G. SHAW.

Three detachments were employed on the new system of "fore and back double levelling" operations during the season.

PERSONNEL.

Provincial Officers.

Mr. H. G. Shaw, in charge.
" D. H. Luxa.
" J. McCraken, up to 31st August.
" T. F. Kitchen.
" M. S. Ganesa Aiyar, up to 5th July.
" Jiya Lal Sahgal.
" Narendra Nath Chuckerbutty.

Upper Subordinate Service.

Mr. Karuna Kumar Das, B.A.

Lower Subordinate Service.

1 Computer.
8 Recorders.
2 Clerks.

No. 1 DETACHMENT.

This detachment was employed on the following lines of levels :—

(1) Levelling from Bareilly to Hāthras along the main road *viâ* Budaun, Kāsganj and Sikandra Rao, crossing the Rāmgangā near Bareilly and the Ganges at Soron by the railway bridges.

(2) Levelling from Multān to Bahāwalpur along the main road *viâ* Lār and Lodhrān, the Sutlej river at Adamwāhan being crossed by the railway bridge.

(3) Revisionary levelling from Meerut to Bareilly along the main road, crossing by railway bridges the rivers Ganges, Rāmgangā and Kosī, at Garhmuktesar, Morādābād and Rāmpur, respectively.

The line Bareilly-Hāthras is an entirely new line and was levelled by two levellers, each working independently from opposite ends of the line. This line breaks up the large circuit, Meerut-Bareilly-Lucknow-Cawnpore-Agra-Hāthras-Meerut (all of which were worked between 1861 and 1869, except the portion Meerut-Bareilly which was revised this season) into two parts, namely, (*a*) Bareilly-Hâthras-Meerut-Bareilly, and (*b*) Bareilly-Lucknow-Cawnpore-Agra-Hāthras-Bareilly. The closing errors being 0·064 and 0·202 of a foot, respectively, as shown below :—

Lines.		Distance in miles.	Observed difference of height in feet.	Year of observation.
Circuit A.				
From To	G. T. S. Standard Bench-mark Bareilly G. T. S. embedded at Hāthras □ B. M. City Railway station.	107·6	+20·158	1914-15
From To	G. T. S. embedded at Hāthras □ B. M. City Railway station G. T. S. Block-stone B. M. Hāthras.	1·2	+0·986	1905-06

Lines.	Distance in miles.	Observed difference of height in feet.	Year of observation.
Circuit A—contd.			
From G. T. S. Block-stone Bench-mark, Hāthras To + at St. John's Church, Meerut.	102·5	+153·294	1861-62
From + at St. John's Church, Meerut To G. T. S. Standard Bench-mark, Bareilly.	134·6	−174·502	1914-15
TOTAL ...	345·9	−0·064	...
Circuit B.			
From G. T. S. Standard Bench-mark, Bareilly To G. T. S. B. M. ○ at Cantonment Church, Bareilly.	1·4	−4·869	1914-15
From G. T. S. B. M. ○ at Cantonment Church, Bareilly To G. T. S. stone Bench-mark at Lucknow.	155·1	−175·890	1867-68 and 69
From G. T. S. stone Bench-mark at Lucknow To G. T. S. stone Bench-mark at Cawnpore.	49·4	+23·438	1868-69
From G. T. S. stone Bench-mark at Cawnpore To × at Goods Station platform, Agra.	168·0	+108·513	1864-65
From × at Goods Station platform, Agra To G. T. S. Block-stone Bench-mark at Hāthras.	30·6	+69·750	1861-62
From G. T. S. Block-stone Bench-mark at Hāthras To G. T. S. B. M. □ embedded at Hāthras City Railway Station.	1·2	−0·986	1905-06
From G. T. S. B. M. □ embedded at Hāthras City Railway Station To G. T. S. Standard Bench-mark at Bareilly.	107·3	−20·158	1914-15
TOTAL ...	513·0	−0·202	...

The line Multān-Bahāwalpur is a new line and was carried out by one leveller who levelled over the line twice, once in the forward and once in the back direction. It closes two circuits, namely, (*a*) Multān-Khemwāla-Murghai-Jamrani-Bahāwalpur-Multān, and (*b*) Multān-Bahāwalpur-Jamrani-Ferozepore-Lahore-Sargodha-Multān. The closing errors being 0·309 and 0·195 of a foot, respectively, as shown below. The circuit (*b*) will be broken into two smaller ones during the field season 1915-16 :—

Lines.	Distance in miles.	Observed difference of height in feet.	Year of observation.
Circuit A.			
From G. T. S. × B. M. embedded at Multān To ⊙ at Khemwāla G. T. S.	38·1	+ 7·880	1866-67
From ⊙ at Khemwāla G. T. S. To Murghai Bench-mark	100·1	—115·974	1859-60
From Murghai Bench-mark To Jamrani Bench-mark	86·5	+ 73·466	1860-61
From Jamrani Bench-mark To G. T. S. Standard Bench-mark at Bahāwalpur.	15·4	+ 14·323	1909-10
From G. T. S. Standard Bench-mark at Bahāwalpur To G. T. S. × B. M. embedded at Multān	59·2	+ 19·996	1914-15
TOTAL .	299·3	—0·309	...
Circuit B.			
From G. T. S. × B. M. embedded at Multān To G. T. S. Standard Bench-mark at Bahāwalpur.	59·2	—19·996	1914-15
From G. T. S. Standard Bench-mark at Bahāwalpur To Jamrani Bench-mark	15·4	— 14·323	1909-10

Lines.	Distance in miles.	Observed difference of height in feet.	Year of observation.
Circuit B—contd.			
From Jámrani Bench-mark To G. T. S. stone Bench-mark at Ferozepore.	225·4	+278·349	1860-61
From G. T. S. stone Bench-mark at Ferozepore To G. T. S. Standard Bench-mark at Lahore Cantonment.	49·1	+63·876	1913-14
From G. T. S. Standard Bench-mark at Lahore Cantonment To G. T. S. □ B. M. at N.-W. Railway Rest House, Sargodha Railway station.	117·2	−94·231	1911-12
From G. T. S. □ B. M. at N.-W. Ry. Rest House, Sargodha Railway station. To G. T. S. × B. M. embedded at Multān.	173·7	−213·480	1911-12 and 13
TOTAL .	640·0	+0·195	...

Revisionary levelling, Meerut to Bareilly viâ *Morādābād.*—The original levelling from Meerut to Bareilly *viâ* Morādābād was carried out in seasons 1867-68-69. The present revision was worked in two parts, *viz.*:—Meerut to Morādābād and Bareilly to Morādābād. The part Meerut to Morādābād was levelled twice over in opposite directions by one leveller only on widely different dates, commencing from Meerut and closing at Morādābād and then working back from Morādābād to Meerut. The part Bareilly to Morādābād was also levelled twice over in opposite directions on widely different dates, but by two levellers starting from opposite ends of the line.

The new height of the standard bench-mark at Bareilly as determined by the present revisionary levelling from Meerut, a distance of 138 miles, differs from the height published in G. T. S. Volume XIX-B, by +0·268 of a foot. The new height of the same bench-mark as deduced from the new line Hāthras-Bareilly, 108 miles in length, also differs from the published height by +0·219 of a foot. The height of the embedded bench-mark at Hāthras City as determined by the present levelling from Meerut *viâ* Bareilly to Hāthras, a distance of 246 miles, only differs from that published in Volume XIX-B, by +0·069 of a foot. It is, therefore, probable that the above discrepancies between Bareilly-Meerut and Bareilly-Hāthras, are due to the unsatisfactory connection, in 1905-06, of the standard bench-mark at Bareilly.

Of the old bench-marks on the Meerut-Bareilly line only 5 were found intact. Of the others some had been reconstructed so as not to be exactly identical with the old bench-marks, others had been disturbed or destroyed, and a good many could not be found at all owing to the vagueness of the descriptions.

No. 2 Detachment.

This detachment carried out levelling operations from *Benares to Barākar* along the Grand Trunk Road, crossing the Son river over the Causeway at Dehrī.

Branch lines for irrigation purposes were also run along the Patna Canal *from Barūn to Belsar and from Bankipore to Bihta.*

It was intended to carry the Benares-Barākar line on to Chāmpdāni, distance about 20 miles from Howrah, and thus complete the line from Benares to Howrah, but this had to be postponed until season 1915-16, as it was too late in the season, the hot weather having set in, to continue work any longer. The progress of work on this line of levels was considerably retarded on account of the undulating nature of the country from near Sherghāti to Barākar.

In the above lines of levels and for those carried out by No. 3 Detachment, each section of the lines of levels was levelled twice over in opposite directions on the same day by two levellers.

No. 3 Detachment.

This detachment had for its programme:—

(1) revisionary levelling from Bellary to Gooty,
(2) to level from Raichūr to Bāgalkot,
(3) to level from Bāgalkot to Bijāpur.

Revision of the line from Bellary to Gooty.—This line was originally levelled in 1873-74. It practically follows the main unmetalled road *viâ* Gadekal and Guntakal to Gooty.

The present levelling shows satisfactory accordance with the 1873-74 work as also with the levelling of 1907-08 as shown in Table III. Seven old bench-marks only of 1873-74, were found and connected, the others having either been reconstructed or destroyed.

The line from Raichūr to Bāgalkot is a new one and completes the line from Belgaum to Raichūr *viâ* Bāgalkot. It was carried along the metalled road from Raichūr to Lingsugūr, thence along a cart track to Hungund, and from there along the metalled road to Bāgalkot *viâ* Sirūr. This section, Raichūr to Bāgalkot, completes the circuit Bāgalkot-Belgaum-Hubli-Bellary-Kosgi-Raichūr-Bāgalkot, all lines of recent levelling.

The closing error being 0·619 of a foot in a distance of 519 miles, as given in the table below.

The orthometric height of the rock cut bench-mark at the Public Works Department Office, Bāgalkot, as deduced from Belgaum and published in G. T. S. Volume XIX-A, is 1719·743 feet; taking the observed difference of level now obtained between the Raichūr Standard and the above bench-mark at Bāgalkot, and applying approximately the orthometric correction, we get

the height of the Bāgalkot bench-mark to be 1719·826 feet. Thus showing a discrepancy of +0·083 of a foot in a distance of 121 miles :—

Lines.	Distance in miles.	Observed difference of height in feet.	Year of observation.
From G. T. S. Standard Bench-mark at Belgaum To G. T. S. □ B. M. at Hubli Traveller's bungalow.	61·0	—462·937	1910-11
From G. T. S. □ B. M. at Hubli Traveller's bungalow To G. T. S. Standard Bench-mark at Bellary Cantonment.	135·4	—538·507	1907-08
From G. T. S. Standard Bench-mark at Bellary Cantonment To G. T. S. O B. M. at M. and S. M. Railway dispensary and hospital, Guntakal.	35·7	—50·254	1914-15
From G. T. S. O B. M. at M. and S. M. Railway dispensary and hospital, Guntakal To G. T. S. □ B. M. at Kosgi Railway station	49·9	—233·313	1907-08
From G. T. S. □ B. M. at Kosgi Railway station To G. T. S. Standard Bench-mark at Raichūr.	28·3	+ 77·180	1906-07
From G. T. S. Standard Bench-mark at Raichūr To G. T. S. O B. M. on rock protected at P. W. D. Office compound, Bāgalkot.	121·4	+404·814	1914-15
From G. T. S. O B. M. on rock protected at P. W. D. Office compound, Bāgalkot To G. T. S. Standard Bench-mark at Belgaum.	87·0	+803·636	1910-11
TOTAL .	519·7	+ 0·619	

The line Bāgalkot-Bijāpur, a new line, was carried along the metalled road, crossing the Krishna (Kistna) river near Kolhar. The levels were carried across this river, which is 550 yards in width, by ordinary levelling. The

instruments were set up on three small rocky islands, the longest shot not exceeding 5 chains. This method of crossing this river is only possible during the dry season, when the water is low. During the monsoons the water rises about 20 or 30 feet and floods the surrounding country.

It was intended to continue this line, by revisionary levelling, from Bijāpur to Sholāpur originally levelled in 1879-80, but it was not found possible to take it up.

The published height given in G. T. S. Volume XIX-A for the bench-mark $\frac{19}{47\text{-P.}}$ at Bijāpur Fort is 1957·124 feet as deduced from Sholāpur, and that now obtained of this same bench-mark is 1957·596 feet by applying the observed difference of level, 237·853 feet, to the published height of the rock cut bench-mark $\frac{84}{47\text{-P.}}$ at Bāgalkot, showing a discrepancy of +0·472 of a foot in a distance of 54 miles. It is difficult to assign any reason for this large discrepancy until the line from Bijāpur to Sholāpur has been revised. For the present that line must be looked upon with suspicion, as we have no reason to doubt either the present levelling, or the height of the initial point at Bāgalkot; it holds good with both Belgaum and Raichūr.

In addition to the above about 50 miles of single levelling were carried out in the Island of Bombay, at the request of the Local Government, in order to provide sufficient bench-marks for the control of the large scale survey of the island which was then in progress.

The lines of levels comprise a main circuit, running right round the island along the principal roads near the coast, six cross lines and two branch lines, the whole forming a network of levelling which supplied numerous checks against errors at short intervals: it was therefore considered unnecessary to employ double-levelling. During the course of this levelling 13 old bench-marks of line No. 32 were reconnected, and the heights above mean sea-level of 142 new embedded and inscribed bench-marks were determined.

GENERAL NOTES.

The details of the outturn of work completed by each detachment during the season under report are given in Table I attached.

The outturn of the detachments amounted to 947 miles. In the course of this levelling 145 miles were relevelled as the differences in height obtained between consecutive bench-marks from the fore and back observations exceeded the assigned limits.

TABLE I.—No. 1 DETACHMENT.

Tabular statement of outturn of work, season 1914-15.

Lines.	Months.	Mean distance levelled in both directions. Main Line. Mls.	Main Line. Chs.	Main Line. Lks.	Extras and Auxiliary. Mls.	Extras and Auxiliary. Chs.	Extras and Auxiliary. Lks.	Total. Mls.	Total. Chs.	Total. Lks.	Mean distance relevelled in both directions. Mls.	Chs.	Lks.	Total number of feet, mean of both directions. Rises.	Falls.	Mean number of stations at which instruments were set up in both directions.	Number of bench-marks connected. Primary. Standard.	Primary. Principal stations of triangulation. Old.	Principal stations of triangulation. New.	Secondary. Embedded. Old.	Embedded. New.	Inscribed. Old.	Inscribed. New.	Irrigation. Old.	Irrigation. New.	Railway.	P. W. D. Old.	P. W. D. New.	Iron bolts.	Zinc plates.	Remarks.
Bareilly-Hāthras	November 1914	65	45	12	14	07	71	79	52	83	7	35	98	612·521	646·494	897	1	...	3	1	11	13	114	...	1	3	1	15	9	...	This line was levelled over by two levellers, working from opposite ends of the line.
	December 1914	41	55	96	6	42	77	48	18	73	24	48	56	350·592	332·029	594															
	TOTALS	107	21	08	20	50	48	127	71	56	32	04	54	963·113	978·523	1491	1	...	3	1	11	13	114	...	1	3	1	15	9	...	
Mul'ān-Bahāwalpur	December 1914 January 1915	58	71	52	5	71	86	64	63	38	8	13	02	394·036	389·624	842	2	1	...	2	4	22	35	1	8	...	...	1	9	...	This line was levelled over in both directions by one leveller only.
	TOTALS	58	71	52	5	71	86	64	63	38	8	13	02	394·036	389·624	842	2	1	...	2	4	22	35	1	8	...	...	1	9	...	
Meerut-Morādābād	February 1915 March 1915	77	47	76	15	29	48	92	77	24	6	66	54	645·365	640·905	1051	2	2	...	...	7	11	119	2	3	...	1	8	1	1	This line was also levelled over in both directions by one leveller only.
	TOTALS	77	47	76	15	29	48	92	77	24	6	66	54	645·365	640·905	1051	2	2	...	...	7	11	119	2	3	...	1	8	1	1	
Bareilly-Morādābād	March 1915 April 1915	55	77	64	0	43	85	56	41	49	8	70	69	493·647	497·097	736	1	1	...	...	6	6	97	...	1	2	2	11	...	8	This line was levelled over by two levellers working from opposite ends of the line.
	TOTALS	55	77	64	0	43	85	56	41	49	8	70	69	493·647	497·097	736	1	1	...	...	6	6	97	...	1	2	2	11	...	8	
	GRAND TOTALS	299	58	00	42	35	67	342	13	67	55	74	79	2496·161	2506·149	4120	6	4	3	3	28	52	365	3	13	5	4	35	19	9	

TABLE I—(*continued*)—No. 2 DETACHMENT.

Tabular statement of outturn of work, season 1914-15.

Lines.	Months.	MEAN DISTANCE LEVELLED IN BOTH DIRECTIONS.									Mean distance relevelled in both directions.			TOTAL NUMBER OF FEET (MEAN OF BOTH DIRECTIONS).		Mean number of stations at which instruments were set up in both directions.	NUMBER OF BENCH-MARKS CONNECTED.												Remarks.
		Main line.			Extras and auxiliary.			Total.						Rises.	Falls.		PRIMARY.				SECONDARY.								
																	Rock cut.	Standard.	Principal G. T. stations.		Embedded.	Inscribed.		P. W. D.	Irrigation.	Zinc plates.	Iron bolts.		
																			Old.	New.		Old.	New.						
		Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	Mls.	Chs.	Lks.	Mls.	Chs.	Lks.																
Benares to Barākar	November 1914	43	71	02	11	23	51	55	14	53	6	14	22	282·256	291·249	616	...	1	1	1	6	7	29	...	...	7	2		
	December "	47	51	41	26	30	38	74	01	79	8	69	37	360·159	269·614	819	...	...	...	...	4	...	40	1	8	20	2		
	January 1915	66	66	76	4	43	85	71	30	61	7	23	69	975·856	751·320	800	2	...	...	...	8	...	34	...	1	25	3		
	February "	50	79	75	2	69	01	53	68	76	8	19	19	1888·642	1185·221	793	30	...	...	1	3	...	16	...	...	1	1		
	March "	63	30	47	......			63	30	47	6	47	34	1963·733	2696·882	920	43	...	...	...	6	...	5	...	...	...	...		
	April "	11	23	97	......			11	23	97	0	48	85	261·682	414·574	162	5	...	...	..	2	...	6	...	...	1	1		
	TOTALS	284	03	38	45	06	75	329	10	13	37	62	66	5732·328	5608·860	4,110	80	1	1	2	29	7	130	1	9	54	9		
Bankipore to Bihta	April 1915	20	76	17	2	08	10	23	04	27	......			135·822	107·759	248	...	1	...	...	...	2	10	...	3	...	...		
	TOTALS	20	76	17	2	08	10	23	04	27	......			135·822	107·759	248	...	1	...	...	...	2	10	...	3	...	...		
	GRAND TOTALS	304	79	55	47	14	85	352	14	40	37	62	66	5868·150	5716·619	4,358	80	2	1	2	29	9	140	1	12	54	9		

TABLE I—(*concluded*)—No. 3 DETACHMENT.

Tabular statement of outturn of work, season 1914-15.

Lines.	Months.	Mean distance levelled in both directions. Main line.	Extras and auxiliary.	Total.	Mean distance relevelled in both directions.	Total number of feet (mean of both directions.) Rises.	Falls.	Mean number of stations at which instruments were set up in both directions.	Number of bench-marks connected. Primary. Standard.	Primary. Rock-cut protected. Old.	Rock-cut protected. New.	Secondary. Embedded. Old.	Embedded. New.	Inscribed. Old.	Inscribed. New.	Rock-cut. Old.	Rock-cut. New.	Iron bolts.	Secondary station of triangulation.	Remarks.
		Mls. Chs. Lks.	Mls. Chs. Lks.	Mls. Chs. Lks.	Mls. Chs. Lks.	Feet.	Feet.													
Bellary to Gooty	November 1914	36 79 76	2 64 68	39 64 44	12 16 64	641·371	743·530	565	1	...	2	...	...	10	20	2	8	...	...	
	December „	20 49 04	3 22 76	23 71 80	3 46 34	388·811	608·421	318	...	...	...	2	...	7	4	1	13	...	1	
	TOTALS	57 48 80	6 07 44	63 56 24	15 62 98	1030·182	1351·951	883	1	...	2	2	...	17	24	3	21	...	1	
Raichūr to Bāgalkot	December 1914	43 42 43	5 11 86	48 54 29	6 47 12	948·801	786·963	586	1	...	3	...	1	2	11	...	19	...	...	
	January 1915	67 60 37	4 07 92	71 68 29	13 34 38	1965·014	1652·404	914	...	...	...	...	7	...	23	...	11	1	...	
	February „	10 09 52	6 03 18	16 12 70	2 36 48	141·103	210·684	110	...	1	...	...	1	1	9	1	...	...	...	
	TOTALS	121 32 32	15 22 96	136 55 28	22 37 98	3054·918	2650·051	1,610	1	1	3	...	9	3	43	1	30	1	...	
Bāgalkot to Bijāpur	February 1915	49 76 80	2 40 48	52 37 28	13 06 49	1350·690	1187·647	631	1	...	...	1	4	4	21	...	1	...	...	
	TOTALS	49 76 80	2 40 48	52 37 28	13 06 49	1350·690	1187·647	631	1	...	...	1	4	4	21	...	1	...	...	
	GRAND TOTALS	228 77 92	23 70 88	252 68 80	51 27 45	5435·790	5189·649	3,124	3	1	5	3	13	24	88	4	52	1	1	

TABLE II—CHECK-LEVELLING.

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected for check-levelling. Number.	Degree sheet.	Description.	Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by Original levelling.	Date.	Check-levelling, 1914-15.	Difference (check-original). The sign + denotes that the height was greater, and the sign — less in 1914-15 than when originally levelled.	Remarks.
			Miles.	Feet.		Feet.	Feet.	
				Check-levelling at Bareilly.				
57	53-P.	Standard Bench-mark.	0·0	0·000	1905-06	0·000	0·000	
55	,,	Culvert . .	0·2	—2·561	1905-06	—2·565	—0·004	
56	,,	Well . . .	0·2	—1·164	1905-06	—1·158	+0·006	Originally connected in 1867-69.
54	,,	Octagonal well .	1·1	—2·889	1905-06	—2·896	—0·007	
53	,,	Step, Cantonment Church.	1·4	—4·875	1905-06	—4·869	+0·006	Ditto.
58	,,	Flooring, Commissioner's office.	0·5	+1·648	1905-06	+1·667	+0·019	
145	,,	Platform, City Ry. station.	1·5	—15·977	1909-10	—15·990	—0·013	
146	,,	Ditto . .	1·6	—15·946	1909-10	—15·951	—0·005	
147	,,	Railway bridge .	2·4	—16·491	1909-10	—16·483	+0·008	
148	,,	Well . . .	2·9	—18·242	1909-10	—18·220	+0·022	
				Check-levelling at Hāthras.				
22	54-I.	Embedded, City Ry. station.	0·0	0·000	1905-06	0·000	0·000	
24	,,	Railway Culvert .	1·3	—2·417	1905-06	—2·415	+0·002	
25	,,	Ditto .	2·7	+1·066	1905-06	+1·072	+0·006	
26	,,	Ditto .	3·3	+0·434	1905-06	+0·442	+0·008	
27	,,	Stone prism .	4·1	—0·125	1905-06	—0·124	+0·001	
28	,,	Platform, overhead station.	5·4	+18·426	1905-06	+18·401	—0·025	
21	,,	Verandah, City Ry. station.	0·0	+2·932	1905-06	+2·931	—0·001	
31	,,	Railway drain .	2·0	—1·985	1905-06	—1·992	—0·007	
1	54-E.	Well . . .	2·7	—2·525	1905-06	—2·510	+0·015	
2	,,	Railway drain .	3·7	—2·698	1905-06	—2·686	+0·012	
				Check-levelling at Multān.				
33	39-N.	Embedded . .	0·0	0·000	1906-07	0·000	0·000	Originally connected in 1866-67.
34	,,	Standard Bench-mark.	0·1	+2·406	1906-07	+2·412	+0·006	
36	,,	Masonry block .	1·1	+2·780	1906-07	+2·785	+0·005	
35	,,	W. end, main platform.	1·2	+6·842	1906-07	+6·848	+ 0·006	
39	,,	Flooring, Barrack No. 4.	0·1	+2·722	1906-07	+2·721	—0·001	

TABLE II—(*contd.*)—CHECK-LEVELLING.

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected for check-levelling. Number.	Degree sheet.	Description.	Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by Original levelling.	Date.	Check-levelling, 1914-15.	Difference (check-original). The sign + denotes that the height was greater, and the sign — less in 1914-15 than when originally levelled.	Remarks.
			Miles.	Feet.		Feet.	Feet.	
				Check-levelling at Multān—contd.				
40	39-N.	Flooring, Barrack No. 1.	0·1	+4·558	1906-07	+4·552	—0·006	
41	,,	Flooring, Steeple Tower.	0·2	+4·880	1906-07	+4·872	—0·008	
42	,,	Chaplain's Office .	0·3	+4·199	1906-07	+4·190	—0·009	
43	,,	Block No. 26, Station Hospital.	0·4	+4·159	1906-07	+4·158	—0·001	
44	,,	Block No. 28, Station Hospital.	0·5	+4·361	1906-07	+4·356	—0·005	
37	,,	Main platform, opposite Main exit.	1·3	+6·867	1906-07	+6·869	+0·002	
38	,,	E. end Main platform.	1·4	+6·925	1906-07	+6·929	+0·004	
				Check-levelling at Bahāwalpur.				
27	39-O.	Standard Bench-mark.	0·0	0·000	1909-10	0·000	0·000	
17	,,	Sadik Egerton College.	0·4	—0·798	1909-10	—0·808	—0·010	
18	,,	Municipal Office .	0·8	—0·930	1909-10	—0·954	—0·024	
19	,,	Guest House .	1·7	—0·150	1909-10	—0·180	—0·030	
20	,,	Bathing *Ghat* .	1·9	+2·436	1909-10	+2·379	—0·057	
22	,,	Bridge . .	2·6	+2·002	1909-10	+1·976	—0·026	
21	,,	Godri Tower Station	2·9	—1·986	1909-10	—2·011	—0·025	
23	,,	Masonry block .	2·7	—7·456	1909-10	—7·494	—0·038	
24	,,	P. W. D. Office .	0·2	+0·502	1909-10	+0·498	—0·004	
25	,,	Stone seat Gulzār Mahal.	0·6	+2·617	1909-10	+2·616	—0·001	
26	,,	Stone step ,, .	0·8	+0·366	1909-10	+0·371	+0·005	
16	,,	,, ,, Victoria Hospital.	0·8	—4·415	1909-10	—4·413	+0·002	
15	,,	Verandah do. .	0·8	—1·285	1909-10	—1·287	—0·002	
14	,,	,, Nūr Mahal	2·3	—0·114	1909-10	—0·110	+0·004	
13	,,	Stone sill Nūr Mahal Mosque.	2·4	—1·207	1909-10	—1·218	—0·011	
12	,,	Bridge . .	4·3	+5·374	1909-10	+5·359	—0·015	

TABLE II—(*contd.*)—CHECK-LEVELLING.

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected for check-levelling.				Observed height above (+) or below (—) starting bench-mark as determined by				
Number.	Degree sheet.	Description.	Distance from starting bench-mark.	Original levelling.	Date.	Check-levelling, 1914-15.	Difference (check-original). The sign + denotes that the height was greater and the sign — less in 1914-15 than when originally levelled.	Remarks.
			Miles.	Feet.		Feet.	Feet.	
				Check-levelling at Meerut.				
26	53-G.	Stone slab St. John's Church.	0·0	—0·000	1905-06	0·000	0·000	Originally connected in 1860-62.
27	„	Standard bench-mark (cantonment).	0·1	—1·300	1905-06	—1·309	—0·009	
28	„	Culvert . .	0·6	—3·260	1905-06	—3·251	+0·009	
72	„	General mile pillar	0·9	—6·644	1905-06	—6·639	+0·005	Originally connected in 1860-62.
29	„	Somru Bridge .	1·3	—4·576	1905-06	—4·574	+0·002	
a*/3	53-H.	Begum's „ .	2·0	—9·033	1912-13	—9·018	+0·015	
3*	„	Law Chamber's buildings.	2·0	—11·091	1912-13	—11·089	+0·002	
b*/2	„	Judge's Court .	2·1	—10·104	1912-13	—10·099	+0·005	
a*/2	„	Treasury . .	2·2	—8·497	1912-13	—8·487	+0·010	
34	53-G.	Suitor's waiting shed.	2·3	—8·826	1905-06	—8·831	—0·005	
35	„	Standard Bench-mark (civil lines).	2·5	—7·975	1905-06	—7·984	—0·009	
e*/1	53-H.	Deputy Collector's Kachari.	2·3	—6·273	1912-13	—6·268	+0·005	
d*/1	„	Divisional College	2·6	—10·643	1912-13	—10·651	—0·008	
c*/1	„	Commissioner's Office.	2·7	—5·825	1912-13	—5·831	—0·006	
33	53-G.	Catch-water .	3·4	—1·936	1905-06	—1·967	—0·031	
				Check-levelling at Benares.				
96	63-K.	Standard Bench-mark.	0·0	0·000	1905-06	0·000	0·000	
95	„	Well . . .	0·0	+0·152	1905-06	+0·172	+0·020	
94	„	Bridge† . .	0·4	—3·811	1905-06	—3·793	+0·018	
88	„	Stone prism† .	0·8	—4·162	1905-06	—4·187	- 0·025	
87	„	Monument† .	1·0	—1·828	1905-06	—1·904	—0·076	
89	„	Well . . .	1·6	—3·032	1905-06	—3·048	—0·016	
90	„	„	2·3	—14·220	1905-06	—14·167	+0·053	
91	„	Stone prism .	2·7	—4·653	1905-06	—4·641	+0·012	
58	63-O.	Barahni T. S. .	34·5	+17·631	1869-70	+17·532	—0·099	

* Temporary Line Form Numbers. Not published.

† These three bench-marks were originally connected in 1863-65. The connection of the standard bench-mark at Benares in 1905-06 depends on the height of the stone prism at the Post Office. Check-levelling was run from this mark to the bench-marks at General Alexander's monument and at the bridge over the Birna river. The discrepancies being —0·114 and —0·021 of a foot, respectively. Accordingly it was assumed that the bench-mark at General Alexander's monument was unreliable. But such is not the case as will be seen from the present check-levelling, as it agrees with another good bench-mark of 1869-70, *viz.*:—that at Barahni T. S.

TABLE II.—(*contd.*)—CHECK-LEVELLING.

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected for check-levelling.			Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by			Difference (check-original). The sign + denotes that the height was greater, and the sign — less in 1914-15 than when originally levelled.	Remarks.
Number.	Degree sheet.	Description.		Original levelling.	Date.	Check-levelling, 1914-15.		
			Miles.	Feet.		Feet.	Feet.	
				Check-levelling at Bankipore.				
19	72-G.	Plinth . .	0·0	0·000	1909-10	0·000	0·000	
20	„	Standard Bench-mark.	0·2	—2·531	1909-10	—2·535	—0·004	
5	„	Step, Christ's Church.	0·6	—2·617	1909-10	—2·601	+0·016	Originally connected in 1863-64.
				Check-levelling at Bellary.				
72	57-A.	Standard Bench-mark.	0·0	0·000	1907-08	0·000	0·000	
71	„	Base of Home signal.	0·4	+4·878	1907-08	+4·873	—0·005	
70	„	Railway bridge .	1·2	—10·400	1907-08	—10·391	+0·009	
69	„	Upright stone .	1·9	+7·108	1907-08	+7·126	+0·018	
68	„	Ditto .	2·4	+12·621	1907-08	+12·654	+0·033	
				Check-levelling at Gooty.				
1	57-E.	Embedded, Railway station.	0·0	0·000	1907-08	0·000	0·000	
124	„	Platform ditto .	0·2	+4·590	1907-08	+4·606	+0·016	
3	„	Step, *Kachari* .	2·1	—18·617	1907-08	—18·617	0·000	
2	„	„ Munro Civil dispensary.	2·2	—21·087	1907-08	—21·080	+0·007	
4	„	Step, Chattram .	2·5	—7·559	1907-08	—7·555	+0·004	
5	„	Pyramidal stone .	3·1	—31·664	1907-08	—31·667	—0·003	
122	„	Railway culvert .	1·5	+1·103	1907-08	+1·137	+0·034	
				Check-levelling at Raichūr.				
74	56-H.	Standard Bench-mark.	0·0	0·000	1906-07	0·000	0·000	
1	„	Embedded, Railway station.	1·4	—5·008	1906-07	—5·014	—0·006	
3	„	Platform, Railway station.	1·5	—0·658	1906-07	—0·655	+0·003	
85	„	Rock . . .	1·7	+10·277	1907-08	+10·455	+0·178	Probably disturbed.
4	„	Railway bridge .	2·8	—14·506	1906-07	—14·480	+0·026	
5	„	Do. culvert .	3·5	—18·174	1906-07	—18·139	+0·035	
2	„	Do. bridge .	1·1	—28·410	1906-07	—28·407	+0·003	
70	„	Do. do. .	2·6	—48·320	1906-07	—48·294	+0·026	

TABLE II—(*concld.*)—CHECK-LEVELLING.

Discrepancies between the old and new heights of bench-marks.

BENCH-MARKS OF THE ORIGINAL LEVELLING THAT WERE CONNECTED FOR CHECK-LEVELLING.			Distance from starting bench-mark.	OBSERVED HEIGHT ABOVE (+) OR BELOW (−) STARTING BENCH-MARK AS DETERMINED BY			Difference (check-original). The sign + denotes that the height was greater, and the sign − less in 1914-15 than when originally levelled.	REMARKS.
Number.	Degree sheet.	Description.		Original levelling.	Date.	Check-levelling, 1914-15.		
			Miles.	Feet.		Feet.	Feet.	
				Check-levelling at Bāgalkot.				
73	47-P.	Embedded . .	0·0	0·000	1910-11	0·000	0·000	
74	"	Culvert . .	0·5	—30·521	1910-11	—30·524	—0·003	
75	"	Rock . . .	1·4	—54·329	1910-11	—54·334	—0·005	
76	"	Do. . . .	2·5	—69·942	1910-11	—69·942	0·000	
77	"	Do. . . .	3·6	—50·214	1910-11	—50·206	+0·008	
78	"	Well . . .	4·1	—58·056	1910-11	—58·038	+0·018	
79	"	Rock . . .	4·6	—72·843	1910-11	—72·821	+0·022	
80	"	Bridge . .	4·8	—72·297	1910-11	—72·273	+0·024	
82	"	Rock . . .	5·5	—69·326	1910-11	—69·292	+0·034	
83	"	Bridge . .	5·6	—71·941	1910-11	—71·907	+0·034	
84	"	Rock cut protected	6·0	—57·632	1910-11	—57·595	+0·037	
				Check-levelling at Bijāpur.				
14	47-P.	Standard Bench-mark.	0·0	0·000	1908-09	0·000	0·000	
12	"	Assar Mahal Tank .	0·4	+12·699	1879-80	+12·699	0·000	
11	"	Bridge . .	0·2	—8·562	1908-09	—8·468	+0·094	Probably disturbed.
19	"	Malika Jahan's Masjid.	0·7	+17·268	1879-80	+17·261	—0·007	
16	"	Platform, Coping Ry. station.	1·3	+3·444	1879-80	+3·433	—0·011	
21	"	Plinth, Taj Bauli .	1·1	+27·179	1908-09	+27·171	—0·008	
22	"	Footing stone steps	1·2	+31·805	1908-09	+31·780	—0·025	
24	"	Step, Ibrāhīm Rauza's Domes.	1·9	+37·947	1879-80	+37·938	—0·009	

TABLE III—Revision levelling.

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected during the revisionary operations.			Distance from starting bench-mark.	Observed height above (+) or below (−) the starting bench-mark as determined by			Difference in height, Revision — Original-levelling. The sign + denotes that the height was greater and the sign − less in 1914-15 than when originally levelled.	Remarks.
Number.	Degree sheet.	Description.		Original levelling.	Date.	Revision, 1914-15.		
			Miles.	Feet.		Feet.	Feet.	
		Revision of line Meerut-Morādābād, part of line No. 64 (Meerut-Lucknow.)						
26	53-G.	Stone slab, St. John's Church.	0·0	0·000	1867-69	0·000	0·000	
72	"	Stone slab, General Mile pillar.	0·9	−6·656	1867-69	−6·639	+0·017	
29	"	Stone slab, Somru bridge.	1·3	−4·576	1867-69	−4·574	+0·002	
91	53-H.	Plinth of mile-post	5·1	−15·780	1867-69	−15·790	−0·010	Inscription cut in 1914-15.
92	"	Stone slab on bridge	5·4	−14·480	1867-69	−14·636	−0·156	Re-constrd.
93	"	Plinth of mile-post	6·1	−15·056	1867-69	−15·021	+0·035	Inscription cut in 1914-15.
94	"	Ditto .	7·1	−14·669	1867-69	−15·114	−0·445	Re-constrd., inscription cut in 1914-15.
96	"	Iron bar at bridge	7·7	−17·002	1867-69	−17·293	−0·291	Ditto.
97	"	Plinth of mile-post .	8·2	−14·724	1867-69	−14·792	−0·068	Inscription cut in 1914-15.
98	"	Ditto .	9·2	−14·893	1867-69	−14·594	+0·299	Re-constrd., inscription cut in 1914-15.
99	"	Ditto .	10·2	−14·544	1867-69	−14·238	+0·306	Ditto.
100	"	Ditto .	11·2	−13·956	1867-69	−14·018	−0·062	Inscription cut in 1914-15.
101	"	Ditto .	12·3	−17·159	1867-69	−16·964	+0·195	Re-constrd., inscription cut in 1914-15.
102	"	Bridge . .	12·7	−17·358	1867-69	−17·414	−0·056	Inscription cut in 1914-15.
103	"	Milestone . .	13·2	−16·817	1867-69	−16·798	+0·019	Ditto.
104	"	Ditto . .	14·2	−19·975	1867-69	−20·064	−0·080	Ditto.
106	"	Ditto . .	15·2	−21·344	1867-69	−21·016	+0·328	Re-constrd., inscription cut in 1914-15.
107	"	Ditto . .	16·2	−26·806	1867-69	−26·830	−0·024	Inscription cut in 1914-15.
108	"	Bridge . .	16·6	−27·454	1867-69	−27·384	+0·070	Ditto.
110	"	Milestone . .	18·2	−16·060	1867-69	−16·353	−0·293	Re-constrd., inscription cut in 1914-15.
114	"	Bridge . .	20·5	−13·706	1867-69	−13·684	+0·022	Inscription cut in 1914-15.

TABLE III—(*contd.*)—REVISION LEVELLING.

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected during the revisionary operations. Number.	Degree sheet.	Description.	Distance from starting bench-mark.	Observed height above (+) or below (—) the starting bench-mark as determined by: Original levelling.	Date.	Revision, 1914-15.	Difference in height, Revision—Original-levelling. The sign + denotes that the height was greater and the sign — less in 1914-15 than when originally levelled.	Remarks.
			Miles.	Feet.		Feet.	Feet.	
		Revision of line Meerut-Morādābād, part of line No. 64 (Meerut-Lucknow)—contd.						
115	53-H.	Mile-post . .	21·2	—27·820	1867-69	—27·512	+0·308	Re-constrd., inscription cut in 1914-15.
116	"	Bridge . .	21·8	—26·689	1867-69	—26·658	+0·031	Inscription cut in 1914-15.
118	"	Do. . .	22·3	—22·080	1867-69	—23·048	—0·968	Re-constrd., inscription cut in 1914-15.
1	53-L.	Mile-post . .	24·2	—31·593	1867-69	—32·076	—0·483	Ditto.
2	"	Do. .	25·2	—33·628	1867-69	—33·803	—0·175	Ditto.
3	"	Do. . .	26·2	—36·814	1867-69	—37·422	—0·608	Ditto.
4	"	Do. . .	27·2	—40·479	1867-69	—40·196	+0·283	Ditto.
5	"	Do. . .	28·2	—39·045	1867-69	—38·747	+0·298	Ditto.
6	"	Do. . .	29·2	—30·552	1867-69	—30·483	+0·069	Inscription cut in 1914-15.
7	"	Culvert . .	29·9	—37·895	1867-69	—39·076	—1·181	Re-constrd., inscription cut in 1914-15.
11	"	Bridge . .	39·7	—75·107	1867-69	—75·073	+0·034	Inscription cut in 1914-15.
12	"	Milestone . .	39·9	—77·927	1867-69	—75·234	+2·693	Re-constrd., inscription cut in 1914-15.
14	"	Bridge . .	41·0	—80·691	1867-69	—80·008	+0·683	Ditto.
15	"	Well . . .	41·9	—73·971	1867-69	—73·943	+0·028	Inscription cut in 1914-15.
17	"	Bridge . .	42·7	—69·943	1867-69	—69·839	+0·104	Ditto.
19	"	Do. . .	43·4	—71·668	1867-69	—70·638	+1·030	Re-constrd., inscription cut in 1914-15.
20	"	Milestone . .	43·9	—62·663	1867-69	—59·829	+2·834	Ditto.
21	"	Do. . .	44·9	—55·182	1867-69	—56·381	—1·199	Ditto.
23	"	Bridge . .	46·4	—55·333	1867-69	—55·578	—0·245	Ditto.
24	"	Milestone . .	46·9	—51·164	1867-69	—50·731	+0·433	Ditto.

TABLE III—(*contd.*)—REVISION LEVELLING.

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected during the revisionary operations.			Distance from starting bench-mark.	Observed height above (+) or below (—) the starting bench-mark as determined by			Difference in height, Revision —Original-levelling. The sign + denotes that the height was greater and the sign — less in 1914-15 than when originally levelled.	Remarks.
Number.	Degree sheet.	Description.		Original levelling.	Date.	Revision, 1914-15.		
			Miles.	Feet.		Feet.	Feet.	
				Revision of line Meerut-Morādābād, part of line No. 64 (Meerut-Lucknow)—contd.				
25	53-L.	Milestone . .	47·9	—50·651	1867-69	—48·730	+1·921	Re-constrd., inscription cut in 1914-15.
26	,,	Do. . .	48·9	—48·512	1867-69	—46·792	+1·720	Ditto.
27	,,	Do. . .	49·9	—48·058	1867-69	—47·138	+0·920	Ditto.
28	,,	Do. . .	50·9	—43·919	1867-69	—44·840	—0·921	Ditto.
29	,,	Do. . .	51·9	—45·774	1867-69	—46·744	—0·970	Ditto.
30	,,	Culvert . .	52·0	—46·432	1867-69	—46·387	+0·045	Inscription cut in 1914-15.
32	,,	Bridge . .	52·4	—46·284	1867-69	—44·840	+1·444	Re-constrd., inscription cut in 1914-15.
34	,,	Do. . .	53·2	—45·624	1867-69	—44·863	+0·761	Ditto.
35	,,	Milestone . .	54·0	—46·466	1867-69	—45·962	+0·504	Ditto.
36	,,	Bridge . .	55·0	—48·381	1867-69	—48·607	—0·226	Ditto.
37	,,	Milestone . .	55·0	—49·469	1867-69	—50·034	—0·565	Ditto.
38	,,	Bridge . .	55·9	—50·315	1867-69	—49·326	+0·989	Ditto.
39	,,	Milestone . .	56·0	—49·784	1867-69	—51·517	—1·733	Ditto.
40	,,	Bridge . .	56·4	—50·790	1867-69	—50·009	+0·781	Ditto.
41	,,	Milestone . .	57·0	—49·870	1867-69	—50·906	—1·036	Ditto.
43	,,	Bridge . .	58·3	—53·951	1867-69	—52·807	+1·144	Ditto.
44	,,	Milestone . .	59·0	—51·839	1867-69	—52·916	—1·077	Ditto.
45	,,	Bridge . .	59·6	—52·507	1867-69	—52·310	+0·197	Ditto.
46	,,	Milestone . .	60·0	—51·282	1867-69	—52·459	—1·177	Ditto.
47	,,	Bridge . .	60·2	—53·333	1867-69	—52·581	+0·752	Ditto.
50	,,	Sirsa T. S. . .	69·1	+0·194	1867-69	+0·283	+0·089	
51	,,	Milestone . .	62·0	—61·058	1867-69	—58·078	+2·980	Re-constrd., inscription cut in 1914-15.
52	,,	Bridge . .	62·7	—59·920	1867-69	—59·406	+0·514	Ditto.
54	,,	Well . . .	63·3	—60·883	1867-69	—60·950	—0·067	Inscription cut in 1914-15.
56	,,	Bridge . .	64·2	—61·832	1867-69	—62·799	—0·967	Re-constrd., inscription cut in 1914-15.

TABLE III—(*contd.*)—REVISION LEVELLING.

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected during the revisionary operations.			Distance from starting bench-mark.	Observed height above (+) or below (—) the starting bench-mark as determined by			Difference in height, Revision —Original-levelling. The sign + denotes that the height was greater and the sign — less in 1914-15 than when originally levelled.	Remarks.
Number.	Degree sheet.	Description.		Original levelling.	Date.	Revision. 1914-15.		
			Miles.	Feet.		Feet.	Feet.	
Revision of line Meerut-Morādābād, part of line No. 64 (Meerut-Lucknow)—concld.								
57	53-L.	Bridge	66·2	—62·836	1867-69	—63·352	—0·516	Re-constrd., inscription cut in 1914-15.
58	,,	Milestone	67·0	—66·987	1867-69	—68·017	—1·030	Ditto.
59	,,	Do.	68·0	—68·929	1867-69	—67·793	+1·136	Ditto.
60	,,	Bridge	68·9	—73·687	1867-69	—72·134	+1·553	Ditto.
62	,,	Milestone	70·1	—74·522	1867-69	—74·353	+0·169	Ditto.
64	,,	Bridge	71·6	—82·073	1867-69	—83·092	—1·019	Ditto.
65	,,	Milestone	72·0	—90·911	1867-69	—89·294	+1·617	Ditto.
66	,,	Bridge	72·3	—96·050	1867-69	—95·660	+0·390	Ditto.
68	,,	Do.	73·3	—98·752	1867-69	—97·180	+1·572	Ditto.
69	,,	Milestone	74·1	—101·891	1867-69	—102·689	—0·798	Ditto.
70	,,	Bridge	74·3	—101·750	1867-69	—101·510	+0·240	Ditto.
71	,,	Do.	74·9	—101·453	1867-69	—102·598	—1·145	Ditto.
73	,,	Do.	75·5	—105·698	1867-69	—104·926	+0·772	Ditto.
74	,,	Do.	75·7	—102·796	1867-69	—103·620	—0·824	Ditto.
78	,,	Do.	77·2	—86·113	1867-69	—86·068	+0·045	Letters B. M. cut in 1914-15.
83	,,	Culvert	78·5	—85·488	1867-69	—85·482	—0·006	Inscription cut in 1914-15.
86	,,	Well	79·6	—87·156	1867-69	—87·084	+0·072	
87	,,	Culvert	79·7	—93·639	1867-69	—93·745	—0·106	Inscription cut in 1914-15.
90	,,	Do.	80·2	—94·763	1867-69	—94·890	—0·127	
92	,,	Bridge	80·9	—85·131	1867-69	—85·213	—0·082	Inscription cut in 1914-15.
93	,,	Bhatauli T. S.	81·6	—49·881	1867-69	—49·931	—0·050	
95	,,	St. Paul's Church, Morādābād.	77·6	—84·709	1867-69	—84·486	+0·223	
Revision of line Bareilly-Morādābād, part of line No. 64 (Meerut-Lucknow).								
57	53-P.	Standard Bench-mark.	0·0	0·000	1905-06	0·000	0·000	
51	,,	Culvert	1·4	—12·739	1867-69	—12·795	—0·056	Inscription cut in 1914-15, appeared re-constructed.

TABLE III—(*contd.*)—REVISION LEVELLING.

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected during the revisionary operations. Number.	Degree sheet.	Description.	Distance from starting bench-mark.	Observed height above (+) or below (—) the starting bench-mark as determined by Original levelling.	Date.	Revision, 1914-15.	Difference in height, Revision—Original-levelling. The sign + denotes that the height was greater and the sign — less in 1914-15 than when originally levelled.	Remarks.
			Miles.	Feet.		Feet.	Feet.	
		Revision of line Bareilly-Morādābād, part of line No. 64 (Meerut-Lucknow)—contd.						
50	53-P.	Milestone	1·6	—15·653	1867-69	—15·749	—0·096	
49	„	Culvert	1·7	—13·503	1867-69	—13·473	+0·030	Inscription cut in 1914-15.
47	„	Do.	2·5	—17·383	1867-69	—17·461	—0·078	Ditto.
46	„	Milestone	2·6	—11·859	1867-69	—11·308	+0·551	Re-constrd.
45	„	Well	3·4	—18·219	1867-69	—18·273	—0·054	
44	„	Milestone	3·7	—17·587	1867-69	—17·651	—0·064	
43	„	Do.	4·7	—15·200	1867-69	—15·262	—0·062	
42	„	Do.	5·7	—15·510	1867-69	—15·581	—0·071	
41	„	Bridge	6·3	—9·521	1867-69	—9·258	+0·263	Re-constrd., inscription cut in 1914-15.
40	„	Milestone	6·7	—14·989	1867-69	—14·790	+0·199	Ditto.
39	„	Bridge	6·8	—10·680	1867-69	—10·570	+0·110	Ditto.
38	„	Do.	7·6	—9·927	1867-69	—10·562	—0·635	Ditto.
37	„	Milestone	7·7	—13·937	1867-69	—14·017	—0·080	
36	„	Bridge	8·1	—9·944	1867-69	—9·069	+0·875	Re-constrd., inscription cut in 1914-15.
34	„	Milestone	8·7	—12·764	1867-69	—12·815	—0·051	
33	„	Bridge	9·0	—9·505	1867-69	—9·056	+0·449	Re-constrd., inscription cut in 1914-15.
31	„	Fatehganj T. S.	11·3	+7·682	1867-69	+7·661	—0·021	
29	„	Bridge	12·2	—2·459	1867-69	—2·580	—0·121	
25	„	Trijunction pillar	14·3	—11·033	1867-69	—11·381	—0·348	Re-constrd.
24	„	Bridge	15·2	—3·511	1867-69	—3·767	—0·256	Re-constrd., inscription cut in 1914-15.
21	„	Culvert	16·9	—2·746	1867-69	—2·975	—0·229	Ditto.
19	„	Bridge	19·0	+6·679	1867-69	+6·546	—0·133	Ditto.

TABLE III—(*contd.*)—Revision levelling.

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected during the revisionary operations.			Distance from starting bench-mark.	Observed height above (+) or below (—) the starting bench-mark as determined by			Difference in height, Revision—Original-levelling. The sign + denotes that the height was greater, and the sign — less in 1914-15 than when originally levelled.	Remarks.
Number.	Degree sheet.	Description.		Original levelling.	Date.	Revision, 1914-15.		
			Miles.	Feet.		Feet.	Feet.	
Revision of line Bareilly-Morādābād, part of line No. 64 (Meerut-Lucknow)—contd.								
18	53-P.	Bridge . .	19·2	+3·352	1867-69	+3·302	—0·050	Inscription cut in 1914-15.
17	,,	Culvert . .	20·7	+5·286	1867-69	+5·374	+0·088	Re-constrd., inscription cut in 1914-15.
14	,,	Bridge . .	23·1	+13·580	1867-69	+13·200	—0·380	Ditto.
12	,,	Culvert . .	25·3	+16·738	1867-69	+16·535	—0·203	Re-constrd.
11	,,	Do. . .	25·7	+17·540	1867-69	+17·346	—0·194	Ditto.
10	,,	Bridge . .	25·8	+19·709	1867-69	+18·876	—0·833	Re-constrd., inscription cut in 1914-15.
9	,,	Do. . .	26·3	+19·044	1867-69	+18·815	—0·229	Ditto.
7	,,	Culvert . .	28·4	+23·061	1867-69	+22·908	—0·153	Ditto.
4	,,	Bridge . .	37·6	+44·276	1867-69	+44·064	—0·212	Ditto.
3	,,	Do. . .	38·2	+46·901	1867-69	+46·761	—0·140	Ditto.
2	,,	Do. . .	39·2	+49·585	1867-69	+49·402	—0·183	Ditto.
1	,,	Do. . .	40·3	+51·033	1867-69	+50·865	—0·168	Ditto.
113	53-L.	Pillar, Encamping ground.	44·1	+51·544	1867-69	+51·325	—0·219	Top damaged.
112	,,	Bridge . .	44·5	+53·208	1867-69	+53·247	+0·039	Inscription cut in 1914-15.
111	,,	Do. . .	45·3	+51·136	1867-69	+50·972	—0·164	Re-constrd., inscription cut in 1914-15.
110	,,	Do. . .	45·5	+52·619	1867-69	+52·433	—0·186	Ditto.
109	,,	Do. . .	46·4	+56·454	1867-69	+56·232	—0·222	Ditto.
108	,,	Do. . .	47·0	+55·308	1867-69	+55·086	—0·222	Damaged, inscription cut in 1914-15.

TABLE III—(*contd.*)—REVISION LEVELLING.

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected during the revisionary operations.			Distance from starting bench-mark.	Observed height above (+) or below (—) the starting bench-mark as determined by			Difference in height, Revision — Original-levelling. The sign + denotes that the height was greater, and the sign — less in 1914-15 than when originally levelled.	Remarks
Number.	Degree sheet.	Description.		Original levelling.	Date.	Revision, 1914-15.		
			Miles.	Feet.		Feet.	Feet.	
		Revision of line Bareilly-Morādābād, part of line No. 64 (Meerut-Lucknow)—concld.						
107	53-L.	Bridge . .	47·2	+54·271	1867-69	+54·003	—0·268	Re-constrd., inscription cut in 1914-15.
106	„	Culvert . .	47·2	+53·830	1867-69	+53·365	—0·465	Doubtful point.
105	„	Bridge . .	48·1	+55·932	1867-69	+55·431	—0·501	Re-constrd., inscription cut in 1914-15.
104	„	Do. . .	48·5	+56·229	1867-69	+55·991	—0·238	Ditto.
102	„	Do. . .	50·6	+65·663	1867-69	+65·315	—0·348	Doubtful point. Inscription cut in 1914-15.
101	„	Do. . .	50·8	+58·407	1867-69	+58·625	+0·218	Re-constrd., inscription cut in 1914-15.
100	„	Do. . .	52·0	+60·801	1867-69	+61·591	+0·790	Ditto.
95	„	St. Paul's Church, Morādābād.	60·1	+90·061	1867-69	+90·016	—0·045	
		Revision of line No. 15 (Bellary-Gooty).						
72	57-A.	Standard Bench-mark.	0·0	0·000	1907-08	0·000	0·000	
73	„	Superintending Engineer's Office.	1·5	— 8·810	1907-08	—8·802	+0·008	
75	„	Plinth of gate post	1·9	—31·242	1907-08	—31·237	+0·005	
8	„	Stone paving of drain	2·0	—40·383	1907-08	—40·378	+0·005	Originally connected in 1873-74
76	„	Railway station platform.	2·2	—36·432	1907-08	—36·430	+0·002	
78	„	Step, Mainwaring tank.	2·5	—47·171	1873-74	—46·876	+0·295	Disturbed.
6	„	Rock . . .	2·8	—44·288	1873-74	—44·285	+0·003	

TABLE III—(*concld.*)— REVISION LEVELLING.

Discrepancies between the old and new heights of bench-marks.

Bench-marks of the original levelling that were connected during the revisionary operations.			Distance from starting bench-mark.	Observed height above (+) or below (—) the starting bench-mark as determined by			Difference in height, Revision—Original-levelling. The sign + denotes that the height was greater and the sign — less in 1914-15 than when originally levelled.	Remarks.
Number.	Degree sheet.	Description.		Original levelling.	Date.	Revision, 1914-15.		
			Miles.	Feet.		Feet.	Feet.	
		Revision of line No. 15 (Bellary-Gooty)—concld.						
5	57-A.	Milestone . .	3·0	—55·480	1873-74	—55·484	—0·004	
4	„	Do. . .	4·0	—78·772	1873-74	—78·975	—0·203	Re-constrd.
3	„	Do. . .	5·0	—102·004	1873-74	—101·993	+0·011	
2	„	Do. . .	6·0	—118·831	1873-74	—118·936	—0·105	Re-constrd.
42	57-E.	Do. . .	9·0	—161·518	1873-74	—161·648	—0·130	Ditto.
37	„	Do. . .	12·1	—169·722	1873-74	—170·489	—0·767	Ditto.
36	„	Pyramidal stone, embedded.	12·9	—156·542	1873-74	—156·507	+0·035	
28	„	Rock . . .	23·5	—59·860	1873-74	—59·907	—0·047	
102	„	Platform Railway Station, Guntakal.	35·4	—48·794	1907-08	—48·767	+0·027	
101	„	Well at Telegraph Office, Guntakal.	35·7	—36·054	1907-08	—36·034	+0·020	
103	„	Railway Dispensary, Guntakal.	35·7	—50·254	1907-08	—50·254	0·000	
105	„	Bridge Railway .	37·0	—102·235	1907-08	—102·233	+0·002	
106	„	Railway platform, Timmancherla.	37·3	—109·483	1907-08	—109·485	—0·002	
107	„	Do. .	37·4	—109·377	1907-08	—109·355	+0·022	
108	„	Embedded at Railway Station.	37·5	—110·055	1907-08	—110·061	—0·006	
24	„	Rock . . .	45·5	—256·184	1873-74	—256·225	—0·041	
20	„	North end Base line, Gooty.	53·6	—354·333	1873-74	—353·933	+0·400	New upper mark-stone.
1	„	Embedded Railway Station, Gooty.	57·6	—321·827	1907-08	—321·852	—0·025	

TABLE IV.

List of Great Trigonometrical Survey Stations connected by Spirit-levelling, season 1914-15.

Name of Station.	Height above mean sea-level.			Difference Old—New.	Remarks.
	New spirit levelling.	Old spirit levelling.	Triangulation.		
Janjīri T. S. (Rangir Meridional Series.)	536·491	...	546·000	+9·509	Metal bolt fixed in mark-stone at ground floor.
Jamālpur T. S. (Budhon Meridional Series).	574·624	...	571·000	—3·624	⊙ at ground floor mark-stone.
Salīmpur T. S. (Budhon Meridional Series).	596·918	...	597·000	+0·082	Ditto.
Godrī T. S. (Sutlej Series)	379·371	378·992	...	—0·379	Ditto.
Sirsa T. S. (Budhon Meridional Series).	738·655	738·566	...	—0·089	⊙ on upper mark-stone at summit of tower.
Bhatauli T. S. (Budhon Meridional Series).	688·441	688·491	...	+0·050	Ditto.
Fatehganj T. S. (Rangir Meridional Series).	571·263	571·284	...	+0·021	Metal bolt on mark-stone at ground floor.
Sikri T. S. (Gora Meridional Series).	296·466	...	293·000	—3·466	Upper mark-stone.
Barhāni T. S. (Gora Meridional Series).	273·678	273·777	...	+0·099	Ditto.
Paraia H. S. (Chendwar Meridional Series).	1574·905	...	1566·000	—8·905	Ditto.

MAGNETIC SURVEY.

No. 18 PARTY.

(*Vide* Index Map No. 16.)

BY MR. E. C. J. BOND.

The present report on the work of the magnetic survey in 1914-15 comprises:—

I.—The account of the work during the field season and in recess quarters.

II.—A note on each of the observatories.

III.—Tables of results, including:—

(*a*) Preliminary values of the magnetic elements at 73 repeat stations.

(*b*) Hourly means and diurnal inequalities of the magnetic elements at each of the four survey base stations in 1914.

An index chart showing the progress of the magnetic survey is appended.

PERSONNEL.

Imperial Officers.

Captain R. H. Thomas, R.E., in charge up to 20th October 1914.

Lieutenant K. Mason, R.E., attached to 24th October 1914.

Provincial Officers.

Mr. E. C. J. Bond, in charge from the 21st October 1914.

Mr. H. P. D. Morton, up to 16th May 1915.

„ R. P. Ray, B.A.

„ N. R. Mazumdar.

„ B. B. Mathur, B.A.

Upper Subordinate Service.

Mr. B. B. Shome.

Lower Subordinate Service.

14 Computers, Recorders, etc.

4 Magnetic Observers, one of whom retired from the service on invalid pension on the 20th July 1915.

I.—FIELD OPERATIONS AND RECESS WORK.

1. *Field operations.*—The field season opened on the 26th October 1914 and closed at the end of April 1915.

The field programme comprised observations for the comparisons of instruments at the four survey base stations and at Alībāg magnetic observatory, and observations at 73 repeat stations in India and Burma for the accurate determination of the secular changes of the magnetic elements.

The Port Blair repeat station which was permanently marked and observed at in previous years, was not visited this season.

Two detachments, each under a Provincial Officer, were employed on the work throughout the field season. As one of these detachments was often delayed from the irregular steamer service along the Burma coast, it was found necessary to send out a third detachment towards the end of the season for two months to assist in the completion of the season's programme.

The 73 repeat stations visited this season include the 22 original repeat stations, 50 selected field stations scattered over India and Burma at distances of 100 to 200 miles apart, and a new repeat station established this season near the Barrackpore observatory which was closed at the end of the season. The 50 stations referred to above were marked in 1910-11 by small masonry pillars,

with the upper surface flush with the ground, as in the case of the previously marked 22 repeat stations. It was found however that many of these pillars were lost or damaged, having been tampered with or destroyed, and since observations at the stations are to be repeated once in every five years there would be some difficulty in the future in identifying the exact position of the stations. In normal areas no sensible error would result in the magnetic elements, at any one time, from a slight change of position, but in the many magnetically disturbed areas in India and Burma the error may vary to a considerable extent, it is therefore important that the exact site is used when observations are repeated at a station to ensure that correct values of the magnetic elements are obtained for the satisfactory determination of the secular changes; for this reason, at the recommendation of the committee* appointed by the Government of India in 1914 to discuss the position of the magnetic survey, the 73 repeat stations were marked in a permanent manner this season by suitable concrete pillars, as described below, and were handed over for preservation to the care of the local authorities so that there shall be no doubt in the future as to their exact position.

Each of the detachment officers was supplied with a collapsible wooden mould 3 feet × 1 foot × 1 foot in dimensions and with this the pillars were constructed without the aid of a mason in the following manner:—A hole was dug in the ground and the mould was let into the centre of the hole which corresponded with the position of the station site. Half a cubic foot of Portland cement, one cubic foot of sand and three cubic feet of rubble were then well mixed with just a sufficient quantity of water to moisten the whole and pressed into the mould; this composition was allowed to set overnight. The next morning the mould was removed and earth filled into the hollow space round the pillar and well beaten down, leaving half a foot of the pillar above the surface of the ground.

The top surface of the pillar was plastered with a mixture of cement and fine sand and the impression "G.T.S. MAGNETIC STATION" was inscribed on it by means of an embossed plate pressed into the moist cement.

The material of which each pillar is composed was tested, before being used, to see that none of it had any magnetic properties and observations were taken at the site before and after the pillar was erected to ascertain whether any difference existed in the observed values.

Each of the 23 repeat stations originally consisted of three sites about a mile to a mile and a half distant from each other and the mean of the magnetic values obtained at each was used to represent the most probable value for the mean geographical position of the three sites. No distinct advantage was however gained in observing at the three sites and to save the additional time and labour involved, it was decided to observe at one site only. The site which appeared, from the results in the past, to give the most normal values for the locality was selected and this was permanently marked as already described.

The officer in charge was employed during the field season, with the assistance of the head-quarters staff of the party, in carrying on the work of the final reduction of the field observations in horizontal force to the selected epoch and in the revision of the preliminary values of the mean magnetic declination from the additional data accumulated during the past few years.

* The committee's report will be found in Part III of the Records for 1913-14.

2. *Work during recess.*—The computations of the field observations taken during the year under report and the reduction and tabulation of the magnetic elements for the four survey base stations (Dehra Dūn, Barrackpore, Kodaikānal, and Toungoo) for 1914 have been completed. The mean values of these elements for the year 1914 have been derived from measurements of all available days, excluding those of great disturbances.

The final reduction of the observations in horizontal force and declination at the repeat and field stations to the selected epoch 1909 is well in hand. The method of reduction as advised by the committee on the magnetic survey appointed by the Government of India in 1914 is being followed.

Good progress has been made with the reductions of the H. F. observations.

Reduction of H. F.

The revised base line values of the Dehra Dūn and Barrackpore H. F. magnetographs have been computed from H as determined from the finally adjusted constants of the magnets of these observatories. The revised base line values of the Kodaikānal observatory are in hand. The corrected monthly mean values of H at the Dehra Dūn observatory have been plotted on a chart and the lines of uniform secular variation derived.

The measurements of the observatories' magnetograms at the times of all the field observations have been completed.

The recomputation of the values of H at the repeat and field stations, necessitated by the revised values of m and ($1+\frac{P}{r^2}+\frac{Q}{r^4}$ etc.) of the field magnets, is in progress.

Reduction of declination.

The reduction of the declination data of the survey was well advanced, but in order that there should be uniformity in the method of reduction of the magnetic elements and to conform to the procedure laid down by the committee on the magnetic survey it has been necessary to recompute the declination data of the field observations; this is now being carried on and it is estimated will take up to the end of June 1916 to complete.

The preparation of a suitable chart of India and Burma will be taken in hand in the meantime and when the reductions are ready all that will be required is to enter the isogonals and lines of equal secular change on it.

3. At the request of the Director of the South Kensington Meteorological Office, London, the magnetic survey party co-operated with the Australasian Antarctic Expedition in 1912 in taking simultaneous magnetic observations at the survey observatories in India and Burma, at prearranged times, to assist the expedition in the comparative study of magnetic disturbances. The results of these observations spread over a period of eight months were submitted this season in convenient form.

Magnetic data were also supplied to Commander A. Alessio of Dr. F. DeFilippi's Expedition for the final reduction of the magnetic observations taken by the expedition in the Karakoram and Chinese Turkistān.

4. *Programme for 1915-16.*—During the ensuing field season one detachment will take the field for about two months, under the officer in charge, to inspect the magnetic observatories and to take the usual observations for the comparisons of instruments at the observatories.

All the members of the party will be employed throughout the season on the reduction of the survey to the selected epoch.

II.—THE OBSERVATORIES IN 1914-15.

A.—DEHRA DŪN OBSERVATORY.

1. The observatory remained in charge of the Magnetic Observer, Babu Sri Dhar, throughout the year.

The H. F. and declination magnetographs have worked satisfactorily during the year.

There has been some improvement in the V. F. instrument by the replacement of the agate plane by a new one but it has not been working quite as satisfactorily as might have been expected. An attempt will be made during the winter to substitute the magnet system of the Barrackpore V. F. instrument which is available since the Barrackpore observatory has been closed.

The V. F. lamp has given trouble by frequently becoming dim at night and there has in consequence been a loss of trace on several occasions. The fault appears to lie in the wick being too big for the small burner of the lamp and since there is a deficiency of oxygen in the underground room to feed the light the wick becomes charred and the light fails. The observer has to trim and adjust the wick very frequently but in spite of this the lamp often smokes and the light goes out.

The Officer in charge of the Mathematical Instrument Office, Calcutta, has been asked to have a burner made with a small opening for a round wick and to adapt it to take a tube shaped chimney: this alteration in the burner it is hoped will overcome the difficulty.

In May 1912 the inner and outer walls of the underground room were plastered with cement to prevent the percolation of water. This is the first year of heavy rain since the plastering was done and it is satisfactory to note that though there has been an accumulation of five feet of water above the outlet pipe in the open pit, the cement plastering has been successful in preventing the percolation of water into the room.

2. *Mean values of declination and H. F. constants.*—The table below gives the mean monthly values of magnetic collimation, the distribution co-efficients P_{1-2} and P_{2-3} and the observed values of m of the observatory magnet used in the computations for 1914. The values of m given in the table are all determined by using the chronograph for the vibration observations.

Mean values of the Constants of Magnet No. 17 in 1914.

MONTHS.	DECLINATION CONSTANTS.	H. F. CONSTANTS.					REMARKS.
		MEAN VALUES OF P'S.			MEAN VALUES OF m.		
	Mean magnetic collimation.	P_{1-2}	P_{2-3}	Accepted value of P_{1-2}	Monthly mean m.	Accepted m.	
	′ ″				811·90	811·90	Up to 24th January.
January	−5 : 52	6·11	6·41	6·02 throughout.	811·30	811·26	From 27th January.
February	−5 : 58	5·97	6·74		811·20		
March	−5 : 57	6·08	6·84		811·37		

Mean values of the Constants of Magnet No. 17 in 1914.

Months.	Declination constants. Mean magnetic collimation.	H. F. Constants. Mean values of P's. P_{1-2}.	P_{2-3}.	Accepted value of P_{1-2}.	Mean values of m. Monthly mean m.	Accepted m.	Remarks.
	′ ″						
April	—6 : 1	6·02	6·78	6·02 throughout.	811·31	811·26	from 27th January.
May	—5 : 58	6·04	6·70		811·19		
June	—5 : 56	6·05	6·87		811·30		
July	—5 : 57	6·08	7·09		811·10		
August	—6 : 2	6·12	6·67		811·22		
September	—6 : 3	6·11	6·69		811·12		
October	—6 : 2	6·05	6·83		811·19		
November	—6 : 3	6·12	6·76		811·25		
December	—6 : 8	6·07	6·75		811·29		

3. ***Mean base line values.***—The table below gives the mean monthly observed and accepted values of the H. F. and declination base lines ; the accepted values have been used to compute the values of these elements for 1914.

Base line values of Magnetographs in 1914.

Months.	Declination. Mean value of Base line.	Base line accepted.	Remarks.	Horizontal Force. Mean value of Base line.	Base line accepted.	Remarks.
	° ′					
January	1 : 31·1	1° : 31′·0 throughout.		·32861	·32861	
February	1 : 31·1			·32861	·32861	
March	1 : 31·0			·32863	·32863	
April	1 : 31·2			·32861	·32861	
May	1 : 31·2			·32860	·32860	
June	1 : 31·0			·32862	·32862	
July	1 : 31·0			·32860	·32860	
August	1 : 30·5			·32856	·32860	Up to 8th.
					·32858	9th and 10th.
					·32856	From 11th.
September	1 : 30·5			·32856	·32856	Up to 13th.
					·32853	14th to 16th.
					·32850	From 17th.

Base line values of Magnetographs in 1914.

MONTHS.	DECLINATION.			HORIZONTAL FORCE.		
	Mean value of Base line.	Base line accepted.	REMARKS.	Mean value of Base line.	Base line accepted.	REMARKS.
	° ′					
October . .	1 : 30·9	1° : 31′·0 throughout.		·32847	·32849	Up to 17th.
					·32847	18th and 19th.
					·32845	20th to 29th.
					·32843	30th and 31st.
November .	1 : 31·0			·32839	·32843	1st and 2nd.
					·32840	3rd to 15th.
					·32839	16th to 30th.
December . .	1 : 31·1			·32834	·32839	Up to 7th.
					·32836	8th to 12th.
					·32833	13th to 17th.
					·32830	From 18th.

4. ***Mean scale values and temperature range.***—The mean scale values for 1914 for an ordinate of $\frac{1}{25}$ inch were as follows :—

H. F. 4·47γ.
Decl. 1·03 minutes.
V. F. 4·52 to 6·07γ.

The mean temperature for the year was 27° C with maximum and minimum monthly values of 27°·1 C and 26°·9 C. The temperature of reduction is 27° C.

5. ***Mean monthly values and secular changes.***—The following table shows the monthly mean values of the magnetic elements for 1913 and 1914 and the secular changes during that period.

Secular changes at Dehra Dūn in 1913-1914.

MONTHS.	HORIZONTAL FORCE ·33000 C. G. S. +			DECLINATION E. 2° +			DIP N. 44° +			VERTICAL FORCE ·32000 C. G. S. +		
	1913.	1914.	Secular change.	1913.	1914.	Secular change.	1913.	1914.	Secular change.	1913.	1914.	Secular change.
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January . . .	199	177	−22	24·0	20·3	−3·7	12·8	19·4	+6·6	299	403	+ 104
February . . .	201	178	23	23·8	20·2	3·6	14·2	19·9	5·7	328	413	85
March	199	175	24	23·3	19·9	3·4	14·8	20·4	5·6	337	420	83
April	194	169	25	22·9	19·6	3·3	15·6	21·7	6·1	348	438	90
May	197	175	22	22·6	19·0	3·6	16·1	22·0	5·9	359	449	90
June	199	175	24	22·3	18·8	3·5	16·2	22·6	6·4	364	461	97
July	196	171	25	22·1	18·6	3·5	16·6	23·2	6·6	367	467	100
August	189	162	27	21·8	18·6	3·2	17·2	24·1	6·9	372	476	104
September . . .	180	158	22	21·4	18·5	2·9	17·8	25·0	7·2	375	490	115
October . . .	177	153	24	21·0	17·9	3·1	18·4	25·2	6·8	384	488	104
November . . .	179	146	33	20·8	17·6	3·2	18·3	25·7	7·4	383	491	108
December . . .	180	145	35	20·4	17·1	3·3	18·8	26·0	7·2	394	497	103
Means	191	165	−26	22·2	18·8	−3·4	16·4	22·9	+6·5	359	458	+99

B.—BARRACKPORE OBSERVATORY.

1. The observatory remained in charge of Magnetic Observer K. N. Mukharji, M.A., up to the 25th April, after which date he was transferred to the head-quarters office of the party at Dehra Dūn.

The declination and H. F. magnetographs worked well during the year. The V. F. magnetograph gave more satisfactory results than is usual with this class of instrument.

2. *Mean values of declination and H. F. constants.*—The following table gives the monthly mean values of magnetic collimation, the distribution co-efficients $P_{1\text{-}3}$ and $P_{2\text{-}3}$ and the moment m of the observatory magnet in 1914.

The moment of the magnet has been constant throughout the year.

Mean values of the Constants of Magnet No. 20 in 1914.

Months.	Declination constants. Mean magnetic collimation.	H. F. constants. Mean values of P's. $P_{1\text{-}2}$	$P_{2\text{-}3}$	Accepted value of $P_{1\text{-}2}$	Mean values of m. Monthly mean m.	Accepted m.	Remarks.
	′ ″						
January	—7 : 30	6·73	7·41	6·67 throughout.	937·22	937·21	
February	—7 : 29	6·61	7·73		937·15		
March	—7 : 22	6·74	7·46		937·05		
April	—7 : 25	6·65	7·35		937·14		
May	—7 : 24	6·71	7·45		937·14		
June	—7 : 23	6·61	7·39		937·16		
July	—7 : 28	6·70	7·52		937·22		
August	—7 : 26	6·68	7·50		937·22		
September	—7 : 25	6·61	7·59		937·12		
October	—7 : 25	6·59	7·56		937·04		
November	—7 : 25	6·58	7·41		937·14		
December	—7 : 23	6·59	7·27		937·22 937·21		By chronograph.

3. *Mean values of Base Lines.*—The table below gives the mean monthly observed and accepted base line values of the declination and H. F. instruments; the accepted values have been used to compute the values of these elements for 1914.

Base line values of Magnetographs in 1914.

Months.	Declination. Mean value of Base line.	Base line accepted.	Remarks.	Horizontal Force. Mean value of Base line.	Base line accepted.	Remarks.
	° ′					
January	—0 : 3·9	—0° : 4′·3 throughout.		·37088	The accepted values are the same as the observed.	
February	—0 : 3·9			·37093		
March	—0 : 4·3			·37096		
April	—0 : 4·5			·37100		
May	—0 : 4·6			·37109		

Base line values of Magnetographs in 1914.

Months.	Declination.			Horizontal Force.		
	Mean value of Base line.	Base line accepted.	Remarks.	Mean value of Base line.	Base line accepted.	Remarks.
	° ′					
June	−0 : 4·4	—0° : 4′·3 throughout.		·37120	The accepted values are the same as the observed.	
July	—0 : 4·5			·37112		
August	—0 : 4·3			·37114		
September	—0 : 4·5			·37117		
October	—0 : 4·5			·37116		
November	−0 : 4·4			·37114		
December	—0 : 4·4			·37109		

4. *Mean scale values and temperature range.*—The mean scale values for the year for an ordinate of $\frac{1}{25}$ inch were:—

H. F. 4·86γ
Decl. 1·03 minutes.
V. F. 4·63γ up to the end of May.
4·44γ from the 1st June.

The mean temperature for the year was 31°·8 C with maximum and minimum monthly values of 33°·2 and 30°·2 C. The temperature of reduction is 31°·0 C.

5. *Mean monthly values and secular changes.*—The following table gives the monthly mean values of the magnetic elements for 1913 and 1914 and the secular changes during that period.

Secular changes at Barrackpore in 1913-14.

Months.	Horizontal Force ·37000 C. G. S. +			Declination E. 0° +			Dip N. 30° +			Vertical Force ·22000 C. G. S.+		
	1913.	1914.	Secular change.	1913.	1914.	Secular change.	1913.	1914.	Secular change.	1913.	1914.	Secular change.
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January	384	396	+ 12	40·6	34·6	−6·0	52·9	56·8	+3·9	357	423	+ 66
February	387	400	13	40·3	34·1	6·2	53·3	57·2	3·9	365	430	65
March	388	399	11	39·8	33·8	6·0	53·5	57·4	3·9	368	433	65
April	376	397	21	39·3	33·4	5·9	54·1	58·0	3·9	371	442	71
May	380	411	31	38·8	32·8	6·0	54·3	58·1	3·8	375	450	75
June	389	418	29	38·3	32·4	5·9	54·5	58·7	4·2	384	464	80
July	389	405	16	37·7	32·0	5·7	55·0	59·1	4·1	391	462	71
August	396	401	5	37·2	31·5	5·7	55·1	59·6	4·5	398	467	69
September	388	400	12	36·8	31·1	5·7	55·7	60·2	4·5	401	475	74
October	389	401	12	36·2	30·7	5·5	56·0	60·3	4·3	406	476	70
November	395	403	8	35·9	30·2	5·7	56·0	61·0	5·0	410	489	79
December	399	409	10	35·5	29·6	5·9	56·7	60·8	4·1	422	490	68
Means	388	403	+ 15	38·0	32·2	−5·8	54·8	58·9	+4·1	387	459	+ 72

Closing of the Barrackpore Observatory.

6. The committee which assembled in March 1914 to discuss the position of the magnetic survey and to advise as to its future programme were of opinion that the maintenance of the observatories of Dehra Dūn, Kodaikānal, Toungoo and Alībāg in continuous operation should give adequate data for determining the

magnetic elements at any time at any place in India, and that the Barrackpore observatory might therefore be closed. On the 26th April 1915 observations at this observatory were discontinued after the repeat stations, whose values are dependent on the Barrackpore observatory for disturbance-corrections, had been permanently marked and observations at them completed. The magnetographs were then dismantled by the officer in charge and the buildings made over to the Bengal Public Works Department on the 3rd May 1915.

All the instruments, furniture etc., of the observatory were sent to Dehra Dūn to be stored away at the head-quarters of the party.

This observatory was built in July 1903. The declination and horizontal force magnetographs were installed in August of the same year and the vertical force magnetograph in April 1907. These instruments have been in operation up to the 25th April 1915.

C.—TOUNGOO OBSERVATORY.

1. Mr. B. B. Shome held charge of the observatory throughout the year.

The H. F. and declination magnetographs have worked well throughout the year; the V. F. magnetograph behaved as well as could be expected of this class of instrument.

2. *Mean values of declination and H. F. constants.*—The table below gives the monthly mean values of magnetic collimation, the distribution co-efficients $P_{1\cdot2}$ and $P_{2\cdot3}$ and the magnetic moment m of the observatory magnet in 1914.

The normal fall of the moment of the magnet has previously been 2·0 C. G. S. per annum as mentioned in last year's report. The fall during this year has been 1·0 C. G. S.; this is still much higher than the average normal fall of the other observatory magnets.

Mean values of the Constants of Magnet No. 19A in 1914.

Months.	Declination constants.	H. F. constants.					Remarks.
		Mean values of P's			Mean values of m.		
	Mean magnetic collimation.	$P_{1\cdot2}$	$P_{2\cdot3}$	Accepted value of $P_{1\cdot2}$	Monthly mean m.	Accepted m.	
	′ ″						
January	−9 : 59	8·25	9·08	8·28 throughout.	878·97	878·97	
February	−9 : 59	8·27	9·04		878·86	878·86	
March	−10 : 1	8·29	9·11		878·70	878·70	
April	−10 : 10	8·26	9·04		878·59	878·59	
May	−10 : 15	8·32	9·11		878·44	878·44	
June	−10 : 2	8·24	9·21		878·31	878·31	
July	−9 : 47	8·34	8·94		878·31	878·31	
August	−9 : 45	8·29	9·07		878·18	878·18	
September	−9 : 52	8·31	8·98		878·15	878·15	
October	−9 : 52	8·29	8·91		878·15	878·15	
November	−10 : 0	8·31	8·87		878·07	878·07	
December	−10 : 2	8·32	8·98		877·92	877·92	

3. *Mean base line values.*—The following table gives the mean monthly observed and accepted base line values of the declination and H. F. magnetographs; the accepted values have been used to compute the values of these elements for 1914.

The observed values of the H. F. base line in this table have been corrected to reduce them to the value of Magnet No. 19, which was in use in the earlier years of the observatory.

Base line values of Magnetographs in 1914.

MONTHS.	DECLINATION.			HORIZONTAL FORCE.		
	Mean value of Base line.	Base line accepted.	REMARKS.	Mean value of Base line.	Base line accepted.	REMARKS.
	° ′					
January	0 : 50·8	0° : 50′·9 throughout.		·38651	The accepted values are the same as the observed.	
February	0 : 50·5			·38648		
March	0 : 50·7			·38643		
April	0 : 50·7			·38646		
May	0 : 50·9			·38641		
June	0 : 50·8			·38636		
July	0 : 50·9			·38635		
August	0 : 50·9			·38629		
September	0 : 51·0			·38629		
October	0 : 51·2			·38632		
November	0 : 51·2			38628		
December	0 : 51·3			·38624		

4. *Mean scale values and temperature range.*—The mean scale values throughout the year for an ordinate of $\frac{1}{25}$ inch were :—

H. F. 5·39γ.
Decl. 1·02 minutes.
V. F. 5·65γ.

The mean temperature for the year was 89° F. with maximum and minimum monthly values of 89°·3 F. and 88°·6 F. The temperature of reduction is 89° F.

5. *Mean monthly values and secular changes.*—The annexed table gives the mean monthly values of H. F. and V. F. for 1912 and 1914, the declination and dip for 1913 and 1914 and the secular changes during those periods. The values of H. F. in 1913 were unsatisfactory and appear to have been

affected by variable personal errors, these have therefore not been used in the tables in deriving the secular changes for the year for H. F. and V. F.

Secular changes at Toungoo in 1912-14.

MONTHS.	HORIZONTAL FORCE ·38000 C. G. S.+			DECLINATION E. O.°+			DIP N. 23°+			VERTICAL FORCE ·16000 C. G. S.+		
	1912.	1914.	Secular change.	1913.	1914.	Secular change.	1913.	1914.	Secular change.	1912.	1914.	Secular change.
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January . . .	866	980	+57	10·1	5·0	−5·1	5·1	5·7	+0·6	531	622	+46
February . . .	872	980	54	9·7	4·4	5·3	4·4	5·8	1·4	539	624	43
March	877	977	50	9·2	4·1	5·1	4·5	5·1	0·6	539	613	37
April	874	978	52	8·7	3·6	5·1	4·8	6·0	1·2	538	625	44
May	880	985	53	8·2	3·2	5·0	5·0	5·9	0·9	541	628	44
June	892	983	46	8·0	2·9	5·1	5·0	5·7	0·7	545	624	40
July	898	985	44	7·5	2·5	5·0	4·9	5·8	0·9	553	626	37
August . . .	891	977	43	6·9	2·0	4·9	5·1	6·1	1·0	543	627	42
September . . .	894	980	43	6·9	1·5	5·4	5·0	6·1	1·1	544	628	42
October . . .	901	987	43	6·4	1·1	5·3	5·4	6·7	1·3	549	639	45
November . . .	900	988	44	5·9	0·7	5·2	5·3	7·0	1·7	568	643	38
December . . .	905	993	44	5·7	0·1	5·6	5·1	6·7	1·6	583	642	30
Means	887	983	+48	7·8	2·6	−5·2	5·0	6·1	+1·1	548	628	+40

D.—KODAIKĀNAL OBSERVATORY.

1. Magnetic Observer Ramasvami Ayyangar held charge of the observatory for about 10½ months of the year and during his absence on leave, from 1st October to 20th November 1914, Computer Abdul Majid was in charge.

Thanks are due to the Director of the Solar Physics Observatory for cordial assistance in all matters connected with the magnetic work.

The magnetographs worked satisfactorily throughout the year.

2. *Mean values of declination and H. F. constants.*—The table below gives the mean observed monthly values of magnetic collimation, the distribution co-efficients $P_{1\text{-}2}$ and $P_{2\text{-}3}$ and the observed and accepted values of the magnetic moment m of the observatory magnet, used in the computations of 1914.

All the values of m were determined by using the chronograph for the vibration observations.

Mean values of the Constants of Magnet No. 16 in 1914.

MONTHS.	DECLINATION CONSTANTS.	H. F. CONSTANTS.					REMARKS.
		MEAN VALUES OF P's.			MEAN VALUES OF m.		
	Mean magnetic collimation.	$P_{1\cdot2}$.	$P_{2\cdot3}$.	Accepted value of $P_{1\cdot2}$.	Monthly mean m.	Accepted m.	
	′ ″						
January	—3 : 27	6·20	8·33	6·29 throughout.	886·44	886·47	
February	—3 : 28	6·27	8·65		886·50		
March	—3 : 26	6·30	8·51		886·32		
April	—3 : 27	6·23	8·52		886·28	886·30	
May	—3 : 29	6·12	8·29		886·30		
June	—3 : 25	6·17	8·40		886·21		
July	—3 : 24	6·25	8·52		886·19	886·24	To September 28th.
August	—3 : 28	6·17	8·57		886·27		
September . . .	—3 : 30	6·14	8·59		886·29		
„	...	...	...			885·79	From September 29th to October 2nd.
October	—3 : 26	6·14	8·51		885·39	885·39	From October 3rd.
November	—3 : 25	6·10	8·52		885·34	885·34	To December 1st.
December	—3 : 26	6·09	8·66		885·03	885·03	From December 3rd.

3. *Mean base line values.*—The following table gives the mean monthly observed and accepted base line values of the H. F. and declination magnetographs; the accepted values have been used to compute the values of these two elements for 1914.

Base line values of Magnetographs in 1914.

MONTHS.	DECLINATION.			HORIZONTAL FORCE.		
	Mean value of Base line.	Base line accepted.	REMARKS.	Mean value of Base line.	Base line accepted.	REMARKS.
	° ′					
January	1 : 58·4	1° : 58′·5 throughout.		·37166	The accepted values are the same as the observed.	
February	1 : 58·8			·37167		
March	1 : 58·4			·37161		
April	1 : 58·7			·37163		Up to 10 hours on 16th April.
„	...			·37349		From 11 hours on 16th April.
May	1 : 59·0			·37346		
June	1 : 58·6			·37346		
July	1 : 58·8			·37345		
August	1 : 58·4			37346		
September	1 : 58·1			·37345		
October	1 : 57·5			·37340		
November	1 : 57·6			·37339		
December	1 : 57·6			·37330		

4. *Mean scale values and temperature range.*—The mean scale values for the year for an ordinate of $\frac{1}{25}$ inch were :—

H. F. 6·01γ to 10 hours on 16th April 1914.
5·93γ from 11 hours ditto.
Decl. 1·03 minutes.
V. F. 4·80γ to 5·46γ.

The mean temperature for the year was 18°·1 C with maximum and minimum monthly values of 18°·7 C. and 17°·1 C. The temperature of reduction is 19° C.

5. *Mean monthly values and secular changes.*—The table below gives the mean monthly values of the magnetic elements for 1913 and 1914 and the secular changes during that period.

Secular changes at Kodaikānal in 1913-14.

MONTHS.	HORIZONTAL FORCE ·37000 C. G. S. +			DECLINATION W. 1° +			DIP N. 4° +			VERTICAL FORCE ·02000 C. G. S. +		
	1913.	1914.	Secular change.	1913.	1914.	Secular change.	1913.	1914.	Secular change.	1913.	1914.	Secular change.
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ
January . . .	554	569	+15	8·7	14·5	+5·8	2·2	8·2	+6·0	650	717	+67
February . . .	548	575	27	9·2	14·9	5·7	2·5	8·5	6·0	653	720	67
March	547	571	24	9·7	15·2	5·5	3·3	9·1	5·8	662	727	65
April	546	570	24	10·0	15·7	5·7	4·2	9·8	5·6	672	734	62
May	549	574	25	10·6	16·3	5·7	4·8	10·5	5·7	678	743	65
June	554	569	15	11·0	16·7	5·7	5·7	11·7	6·0	688	756	68
July	553	569	16	11·4	17·1	5·7	6·1	12·0	5·9	692	759	67
August	558	567	9	11·9	17·5	5·6	6·5	12·5	6·0	698	764	66
September . . .	557	575	18	12·4	18·3	5·9	6·8	12·5	5·7	701	765	64
October . . .	556	572	16	12·9	19·3	6·4	7·6	12·7	5·1	710	766	56
November . . .	560	570	10	13·3	19·8	6·5	7·7	13·7	6·0	710	778	68
December . . .	558	572	14	13·8	20·2	6·4	8·0	13·5	5·5	714	775	61
Means	553	571	+18	11·2	17·1	+5·9	5·5	11·2	+5·7	686	750	+64

III.—TABLES OF RESULTS.

A. Mean values of the magnetic elements at the observatories for 1914

B. Classification of curves and dates of magnetic disturbances in 1914.

C. Tables of results at Dehra Dūn.

D. ,, ,, ,, ,, Barrackpore.

E. ,, ,, ,, ,, Toungoo.

F. ,, ,, ,, ,, Kodaikānal.

For each observatory the following tables are given :—

(*a*) Hourly means (corrected for temperature) of declination, H. F., V. F., and dip from all available days.

(*b*) Diurnal inequality deduced from (*a*).

G. Preliminary values of the magnetic elements at repeat stations in 1914-15.

A.—*Mean values of the magnetic elements at observatories for 1914.*

Observatory.	Latitude and Longitude.	Dip.	Declination.	H. F.	V. F.
	° ′ ″	° ′	° ′	C. G. S.	C. G. S.
Debra Dūn .	30 : 19 : 19 N. 78 : 3 : 19 E.	N. 44 : 22·9	E. 2 : 18·8	·33165	·32458
Barrackpore .	22 : 46 : 29 N. 88 : 21 : 39 E.	N. 30 : 58·9	E. 0 : 32·2	·37403	·22459
Toungoo .	18 : 55 : 45 N. 96 : 27 : 3 E.	N. 23 : 6·1	E. 0 : 2·6	·38983	·16628
Kodaikānal .	10 : 13 : 50 N. 77 : 27 : 46 E.	N. 4 : 11·2	W. 1 : 17·1	·37571	·02750

D = Debra Dûn . { Lat. 30 : 19 : 19 N. Long. 78 : 3 : 19 E.

B = Barrackpore . { Lat. 22 : 46 : 29 N. Long. 88 : 21 : 39 E.

T = Toungoo . { Lat. 18 : 55 : 45 N. Long. 96 : 27 : 3 E.

K = Kodaikānal . { Lat. 10 : 13 : 50 N. Long. 77 : 27 : 46 E.

B.—Classification of curves and dates of Magnetic disturbances in 1914.

Date.	January.				February.				March.				April.				May.				June.			
1914	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K
1	C	C	C	C	C	C	C	C	S	S	S	S	S	S	S	S	C	C	C	C	M	M	M	M
2	S	S	S	S	C	C	C	C	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S
3	S	S	S	C	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	C	S	S	S	S
4	C	C	C	C	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	S	S	S	C
5	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	S	S	S	S	—	C	C	C
6	S	S	S	S	S	S	S	S	S	S	S	S	G	G	G	G	S	S	S	S	S	S	S	S
7	S	S	S	S	S	S	S	S	S	S	S	S	G	G	G	M	S	S	S	C	S	S	S	C
8	S	S	S	S	C	C	C	C	C	C	C	C	M	M	M	S	C	C	C	C	S	S	S	S
9	C	C	C	C	S	S	S	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
10	C	C	C	C	C	C	C	C	S	S	S	C	S	S	S	S	C	C	C	C	S	C	C	C
11	C	C	C	C	C	C	C	C	S	S	S	S	C	C	C	C	S	S	S	S	C	C	C	C
12	S	S	S	S	C	C	C	C	S	S	S	S	C	C	C	C	—	S	S	C	C	C	C	C
13	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	C	—	C	C	C	C	C	C	C
14	C	C	C	C	S	C	C	C	S	S	S	S	C	C	C	C	C	C	C	C	C	C	C	C
15	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	C	C	C	C
16	S	S	S	S	C	C	C	C	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C
17	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	M	M	M	M	C	C	C	C
18	C	C	C	C	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	S	C	C	C	C
19	C	C	C	C	C	C	C	C	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	S
20	C	C	C	C	C	C	C	C	—	S	S	S	C	C	C	C	C	C	C	C	S	S	S	S
21	C	C	C	C	C	C	C	C	—	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
22	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
23	S	S	S	S	S	S	S	S	C	C	C	C	S	C	C	C	C	C	C	C	C	C	C	C
24	C	C	C	C	S	S	S	S	C	C	C	C	S	S	S	C	C	C	C	C	C	C	C	C
25	C	C	C	C	C	C	C	C	S	S	S	S	C	C	C	C	C	C	C	C	S	S	S	S
26	C	C	C	C	C	C	C	C	S	C	C	C	C	C	C	C	S	S	S	S	S	S	S	S
27	C	C	C	C	C	C	C	C	S	C	C	C	C	S	C	S	S	S	S	S	S	S	S	S
28	S	S	S	S	S	S	S	C	C	C	C	C	S	S	S	S	S	S	S	S	S	S	S	S
29	C	C	C	C	...	...	...	...	C	C	C	C	C	C	C	C	C	C	C	C	S	S	S	S
30	C	C	C	C	...	...	...	...	C	C	C	C	C	C	C	C	C	C	C	C	S	S	S	S
31	C	C	C	C	...	...	...	...	S	C	C	C	...	...	...	...	M	M	M	M	...	...	...	...
C	17	17	17	18	13	14	14	17	11	15	15	16	18	18	19	20	18	19	19	20	14	16	16	17
S	14	14	14	13	15	14	14	11	18	16	16	15	9	9	8	8	9	10	10	9	14	13	13	12
M	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	1	2	2	2	2	1	1	1	1
G	...	...	...	...	...	...	...	...	...	...	...	...	2	2	2	1	...	...	...	...	...	...	...	...
Trace lost	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	2	...	...	...	1	...	...	...

Date.	July.				August.				September.				October.				November.				December.				Remarks.
1914	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	
1	C	C	C	C	S	S	S	S	C	C	C	C	S	S	S	S	S	S	S	S	C	C	C	C	
2	C	C	C	C	S	S	S	S	C	C	C	C	S	S	S	S	C	C	C	C	C	C	C	C	
3	C	C	C	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	
4	C	C	C	C	S	S	S	S	S	S	S	S	S	C	C	C	S	S	S	S	S	S	S	S	
5	M	M	M	M	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	S	S	S	S	
6	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	
7	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	S	S	S	S	S	S	S	S	
8	C	C	C	C	S	S	S	S	C	C	C	C	S	S	S	S	C	C	C	C	S	S	S	S	
9	S	C	C	C	C	C	C	C	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	
10	S	S	S	S	C	C	C	C	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	
11	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	C	C	C	C	
12	C	C	C	C	S	S	S	C	C	C	C	S	C	C	C	C	S	S	S	S	C	C	C	C	
13	S	C	C	C	S	S	S	S	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
14	S	C	C	C	S	C	C	C	C	C	C	C	C	C	C	C	S	S	S	S	C	C	C	C	
15	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	S	S	S	S	C	C	C	C	
16	S	S	S	S	C	C	C	C	S	S	S	S	C	C	C	C	S	S	S	S	S	S	S	S	
17	S	S	S	S	C	C	C	C	C	C	C	C	S	S	S	S	S	S	S	S	S	S	S	S	
18	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	
19	C	C	C	C	S	S	S	S	S	S	S	C	S	S	S	S	S	S	S	S	S	S	S	S	
20	C	C	C	S	S	S	S	S	C	C	C	C	S	S	S	S	C	C	C	C	C	C	C	C	
21	S	S	S	S	C	C	C	C	C	C	C	C	S	S	S	S	C	C	C	C	C	C	C	C	
22	S	S	S	S	C	C	C	C	C	C	C	C	S	S	S	S	C	C	C	C	S	S	S	S	
23	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	C	C	C	C	
24	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	S	S	S	S	
25	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	S	S	S	S	
26	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	C	C	C	C	
27	S	S	S	S	S	S	S	C	G	G	G	M	G	M	S	S	S	S	S	S	S	S	S	S	
28	S	S	S	S	S	S	S	S	M	S	S	S	G	M	S	S	S	S	S	S	S	S	S	S	
29	G	G	G	M	S	S	S	S	S	S	S	S	G	M	M	M	S	S	S	S	S	S	S	S	
30	M	M	M	M	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	C	S	S	S	S	
31	S	S	S	S	S	S	S	S	...	...	...	...	C	C	C	C	...	...	...	...	S	S	S	S	
C	9	12	12	11	7	8	8	10	12	12	12	12	12	13	13	13	12	12	12	13	14	14	14	14	
S	19	16	16	17	24	23	23	21	16	17	17	17	16	15	17	17	18	18	18	17	17	17	17	17	
M	2	2	2	3	...	...	...	...	1	...	...	1	...	3	1	1	...	...	...	...	...	...	...	...	
G	1	1	1	...	...	...	...	...	1	1	1	...	3	...	...	...	...	...	...	...	...	...	...	...	
Trace lost	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	

C = Calm. S = Slight. M = Moderate. G = Great. — = Trace lost.

C.—*Tables of results at Dehra Dūn.*

Hourly Means of the Declination as determined at Dehra Dūn from all available days in 1914.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
												Winter.														
			E 2°+																							
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	20·4	20·4	20·3	20·2	20·1	20·0	19·8	19·8	20·0	20·4	20·4	19·8	19·6	20·1	20·8	21·2	20·8	20·4	20·4	20·4	20·4	20·4	20·4	20·4	20·4	20·3
February .	20·3	20·4	20·4	20·3	20·2	20·2	20·0	20·0	20·1	20·2	20·0	19·5	19·2	19·3	20·1	20·7	21·0	20·6	20·3	20·3	20·3	20·3	20·3	20·3	20·3	20·2
March .	20·0	20·0	20·0	19·9	20·0	19·9	19·9	20·2	21·4	21·8	21·5	20·3	18·9	18·0	18·0	18·8	19·7	20·0	19·9	19·8	19·7	19·8	19·9	20·0	20·0	19·9
October .	18·1	18·0	17·9	17·8	17·9	17·9	17·9	18·6	19·5	19·5	18·8	17·3	16·0	15·8	16·5	17·7	18·3	18·2	17·8	17·8	17·8	17·8	18·0	18·1	18·1	17·9
November .	17·9	17·8	17·7	17·5	17·3	17·3	17·1	17·3	17·9	18·3	18·0	17·2	16·7	16·8	17·1	17·5	17·8	17·8	17·9	17·9	17·8	17·8	17·9	17·9	17·9	17·6
December .	17·4	17·3	17·1	17·0	16·9	16·7	16·5	16·3	16·6	17·5	18·0	17·5	16·9	16·8	16·7	16·7	16·9	17·1	17·1	17·2	17·2	17·2	17·4	17·3	17·5	17·1
Means .	19·0	19·0	18·9	18·8	18·7	18·7	18·5	18·7	19·3	19·6	19·5	18·6	17·9	17·8	18·2	18·8	19·1	19·0	18·9	18·9	18·9	18·9	19·0	19·0	19·0	18·8
												Summer.														
April .	20·0	19·9	19·9	19·8	19·8	19·8	20·0	21·0	22·0	22·1	20·8	18·9	17·6	17·2	17·4	18·1	18·8	19·3	19·3	19·3	19·4	19·6	19·8	19·9	20·0	19·6
May .	19·4	19·5	19·5	19·5	19·4	19·6	20·5	21·6	22·0	21·3	19·8	17·8	16·5	16·1	16·4	17·3	18·2	18·9	19·0	18·7	18·7	18·9	19·1	19·3	19·4	19·0
June .	19·1	19·3	19·3	19·4	19·4	19·6	20·6	21·6	21·7	20·8	19·2	17·4	16·3	16·0	16·1	16·8	17·5	18·3	18·6	18·5	18·5	18·5	18·8	18·9	19·1	18·8
July .	18·8	18·9	19·1	19·1	19·2	19·5	20·7	21·6	21·5	20·6	19·1	17·3	16·2	15·7	15·9	16·4	17·2	18·0	18·5	18·4	18·3	18·4	18·5	18·7	18·8	18·6
August .	18·7	18·9	18·9	19·0	19·1	19·4	20·7	21·8	22·0	20·8	18·7	16·6	15·5	15·4	15·9	17·0	18·1	18·8	19·1	18·6	18·5	18·5	18·7	18·7	18·8	18·6
September .	18·7	18·7	18·8	18·9	19·0	19·1	19·9	21·0	21·5	20·5	18·5	16·2	15·1	15·4	16·2	17·5	18·6	18·8	18·5	18·4	18·4	18·5	18·5	18·6	18·7	18·5
Means .	19·1	19·2	19·3	19·3	19·3	19·5	20·4	21·4	21·8	21·0	19·4	17·4	16·2	16·0	16·3	17·2	18·1	18·7	18·8	18·7	18·6	18·7	18·9	19·0	19·1	18·8

Diurnal Inequality of the Declination at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·1	+0·1	0	-0·1	-0·2	-0·3	-0·5	-0·5	-0·3	+0·1	+0·1	-0·5	-0·7	-0·2	+0·5	+0·9	+0·5	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1
February	+0·1	+0·2	+0·2	+0·1	0	0	-0·2	-0·2	-0·1	0	-0·2	-0·7	-1·0	-0·9	-0·1	+0·5	+0·8	+0·4	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1
March	+0·1	+0·1	+0·1	0	+0·1	0	0	+0·3	+1·5	+1·9	+1·6	+0·4	-1·0	-1·9	-1·9	-1·1	-0·2	+0·1	0	-0·1	-0·2	-0·1	0	+0·1	+0·1
October	+0·2	+0·1	0	-0·1	0	0	0	+0·7	+1·6	+1·6	+0·9	-0·6	-1·9	-2·1	-1·4	-0·2	+0·4	+0·3	-0·1	-0·1	-0·1	-0·1	+0·1	+0·2	+0·2
November	+0·3	+0·2	+0·1	-0·1	-0·3	-0·3	-0·5	-0·3	+0·3	+0·7	+0·4	-0·4	-0·9	-0·8	-0·5	-0·1	+0·2	+0·2	+0·3	+0·3	+0·2	+0·2	+0·3	+0·3	+0·3
December	+0·3	+0·2	0	-0·1	-0·2	-0·4	-0·6	-0·8	-0·5	+0·4	+0·9	+0·4	-0·2	-0·3	-0·4	-0·4	-0·2	0	0	+0·1	+0·1	+0·1	+0·3	+0·2	+0·4
Means	+0·2	+0·2	+0·1	0	-0·1	-0·1	-0·3	-0·1	+0·5	+0·8	+0·7	-0·2	-0·9	-1·0	-0·6	0	+0·3	+0·2	+0·1	+0·1	+0·1	+0·1	+0·2	+0·2	+0·2
Summer.																									
April	+0·4	+0·3	+0·3	+0·2	+0·2	+0·2	+0·4	+1·4	+2·4	+2·5	+1·2	-0·7	-2·0	-2·4	-2·2	-1·5	-0·8	-0·3	-0·3	-0·3	-0·2	0	+0·2	+0·3	+0·4
May	+0·4	+0·5	+0·5	+0·5	+0·4	+0·6	+1·5	+2·6	+3·0	+2·3	+0·8	-1·2	-2·5	-2·9	-2·6	-1·7	-0·8	-0·1	0	-0·3	-0·3	-0·1	+0·1	+0·3	+0·4
June	+0·3	+0·5	+0·5	+0·6	+0·6	+0·8	+1·8	+2·8	+2·9	+2·0	+0·4	-1·4	-2·5	-2·8	-2·7	-2·0	-1·3	-0·5	-0·2	-0·3	-0·3	-0·3	0	+0·1	+0·3
July	+0·2	+0·3	+0·5	+0·5	+0·6	+0·9	+2·1	+3·0	+2·9	+2·0	+0·5	-1·3	-2·4	-2·9	-2·7	-2·2	-1·4	-0·6	-0·1	-0·2	-0·3	-0·2	-0·1	+0·1	+0·2
August	+0·1	+0·3	+0·3	+0·4	+0·5	+0·8	+2·1	+3·2	+3·4	+2·2	+0·1	-2·0	-3·1	-3·2	-2·7	-1·6	-0·5	+0·2	+0·5	0	-0·1	-0·1	+0·1	+0·1	+0·2
September	+0·2	+0·2	+0·3	+0·4	+0·5	+0·6	+1·4	+2·5	+3·0	+2·0	0	-2·3	-3·4	-3·1	-2·3	-1·0	+0·1	+0·3	0	-0·1	-0·1	0	0	+0·1	+0·2
Means	+0·3	+0·4	+0·5	+0·5	+0·5	+0·7	+1·6	+2·6	+3·0	+2·2	+0·6	-1·4	-2·6	-2·8	-2·5	-1·6	-0·7	-0·1	0	-0·1	-0·2	-0·1	+0·1	+0·2	+0·3

NOTE.—When the sign is + the magnet points to the East, and when − to the West of the mean position.

Hourly Means of Horizontal Force in C. G. S. units (Corrected for temperature) at Dehra Dūn from all available days in 1914.

·33000 C. G. S. +

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	172	173	173	174	174	174	176	180	182	182	181	186	190	191	186	181	177	173	173	172	171	171	170	171	172	177
February	172	172	174	175	174	174	176	176	177	180	182	189	194	195	191	186	179	175	173	172	169	170	169	171	172	178
March	173	172	172	173	173	174	175	172	173	175	181	182	183	185	184	179	174	171	171	171	171	173	171	171	173	175
October	151	152	152	154	153	154	154	155	149	146	149	158	163	165	163	156	150	149	149	148	149	150	150	153	153	153
November	142	142	143	144	146	146	148	150	153	152	152	154	155	152	148	145	143	143	139	137	137	139	141	141	142	146
December	139	140	142	142	143	144	146	150	155	157	156	155	151	146	142	142	143	143	143	144	143	141	140	142	139	145
Means	158	159	159	160	161	161	163	164	165	165	167	171	173	172	169	165	161	159	158	157	157	157	157	158	159	162
Summer.																										
April	164	166	166	168	168	168	170	169	164	165	167	173	180	184	183	180	173	169	166	164	164	165	165	165	165	169
May	173	171	173	173	173	173	175	171	167	166	171	179	186	189	187	184	180	174	171	170	170	171	171	171	173	175
June	174	175	174	174	173	174	174	174	172	171	176	181	186	187	185	181	176	171	171	171	170	172	173	175	174	175
July	172	171	171	171	170	171	172	172	169	167	168	171	175	180	179	177	172	168	165	164	167	168	169	171	172	171
August	163	163	163	163	163	164	165	160	156	154	156	161	168	171	170	170	167	160	156	156	159	161	161	161	163	162
September	160	159	160	160	160	161	160	154	147	145	146	154	164	171	172	167	161	157	154	153	153	155	156	158	160	158
Means	168	168	168	168	168	169	169	167	163	161	164	170	177	180	179	177	172	167	164	163	164	165	166	167	168	168

Diurnal Inequality of the Horizontal Force at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	−5	−4	−4	−3	−3	−3	−1	+3	+5	+5	+4	+9	+13	+14	+9	+4	0	−4	−4	−5	−6	−6	−7	−6	−5
February	−6	−6	−4	−3	−4	−4	−2	−2	−1	+2	+4	+11	+16	+17	+13	+8	+1	−3	−5	−6	−9	−8	−9	−7	−6
March	−2	−3	−3	−2	−2	−1	0	−3	−2	0	+6	+7	+8	+10	+9	+4	−1	−4	−4	−4	−4	−2	−4	−4	−2
October	−2	−1	−1	+1	0	+1	+1	+2	−4	−7	−4	+5	+10	+12	+10	+3	−3	−4	−4	−5	−4	−3	−3	0	0
November	−4	−4	−3	−2	0	0	+2	+4	+7	+6	+6	+8	+9	+6	+2	−1	−3	−3	−7	−9	−9	−7	−5	−5	−4
December	−6	−5	−3	−3	−2	−1	+1	+5	+10	+12	+11	+10	+6	+1	−3	−3	−2	−2	−2	−1	−2	−4	−5	−3	−6
Means	−4	−3	−3	−2	−1	−1	+1	+2	+3	+3	+5	+9	+11	+10	+7	+3	−1	−3	−4	−5	−5	−5	−5	−4	−3
Summer.																									
April	−5	−3	−3	−1	−1	−1	+1	0	−5	−4	−2	+4	+11	+15	+14	+11	+4	0	−3	−5	−5	−4	−4	−4	−4
May	−2	−4	−2	−2	−2	−2	0	−4	−8	−9	−4	+4	+11	+14	+12	+9	+5	−1	−4	−5	−5	−4	−4	−4	−2
June	−1	0	−1	−1	−2	−1	−1	−1	−3	−4	+1	+6	+11	+12	+10	+6	+1	−4	−4	−4	−5	−3	−2	0	−1
July	+1	0	0	0	−1	0	+1	+1	−2	−4	−3	0	+4	+9	+8	+6	+1	−3	−6	−7	−4	−3	−2	0	+1
August	+1	+1	+1	+1	+1	+2	+3	−2	−6	−8	−6	−1	+6	+9	+8	+8	+5	−2	−6	−6	−3	−1	−1	−1	+1
September	+2	+1	+2	+2	+2	+3	+2	−4	−11	−13	−12	−4	+6	+13	+14	+9	+3	−1	−4	−5	−5	−3	−2	0	+2
Means	0	0	0	0	0	+1	+1	−1	−5	−7	−4	+2	+9	+12	+11	+9	+4	−1	−4	−5	−4	−3	−2	−1	0

NOTE.—When the sign is + the H. F. is greater, and when — it is less than the mean.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Dehra Dūn from all available days in 1914.

·32000 C. G. S. +

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	403	404	403	403	403	403	403	403	404	403	401	398	402	404	405	405	403	402	404	403	404	404	404	404	404	403
February .	414	413	414	413	413	412	412	412	413	412	410	410	410	413	414	415	413	412	412	412	413	413	414	414	414	413
March .	423	422	422	422	422	422	421	424	425	422	416	408	406	409	415	419	421	421	421	421	422	422	422	423	423	420
October .	489	489	489	489	489	489	489	492	493	489	485	480	478	481	486	489	490	489	489	490	490	490	491	491	490	488
November .	492	491	491	491	491	491	491	492	493	490	486	484	485	487	489	492	493	493	493	493	494	494	494	494	493	491
December .	497	497	497	497	497	497	497	497	498	498	496	493	493	493	493	496	498	498	498	498	498	497	497	498	497	497
Means .	453	453	453	453	453	452	452	453	454	452	449	446	446	448	450	453	453	453	453	453	454	453	454	454	454	452
Summer.																										
April .	441	441	441	441	440	440	442	444	442	436	428	423	425	429	433	437	438	440	439	439	440	441	442	442	442	438
May .	454	453	453	453	453	454	457	456	452	445	438	434	436	440	443	448	451	452	451	451	452	453	454	453	454	449
June .	465	465	464	464	464	466	469	468	462	455	449	444	447	450	454	458	462	464	464	461	464	465	466	466	465	461
July .	471	471	471	471	471	473	476	474	470	464	457	450	452	456	458	464	468	471	470	469	471	472	472	473	472	467
August .	481	481	480	480	480	481	484	483	479	472	467	462	462	466	471	475	477	478	479	477	479	480	480	480	480	476
September .	492	492	492	492	492	492	494	495	493	487	480	476	479	485	489	492	493	491	490	491	492	493	493	493	493	490
Means .	467	467	467	467	467	468	470	470	466	460	453	448	450	454	458	462	465	466	466	465	466	467	468	468	468	464

Diurnal Inequality of the Vertical Force at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	0	+1	0	0	0	0	0	0	+1	0	−2	−5	−1	+1	+2	+2	0	−1	+1	0	+1	+1	+1	+1	+1
February	+1	0	+1	0	0	−1	−1	−1	0	−1	−3	−3	−3	0	+1	+2	0	−1	−1	−1	0	0	+1	+1	+1
March	+3	+2	+2	+2	+2	+2	+1	+4	+5	+2	−4	−12	−14	−11	−5	−1	+1	+1	+1	+1	+2	+2	+2	+3	+3
October	+1	+1	+1	+1	+1	+1	+1	+4	+5	+1	−3	−8	−10	−7	−2	+1	+2	+1	+1	+2	+2	+2	+3	+3	+2
November	+1	0	0	0	0	0	0	+1	+2	−1	−5	−7	−6	−4	−2	+1	+2	+2	+2	+2	+3	+3	+3	+3	+2
December	0	0	0	0	0	0	0	0	+1	+1	−1	−4	−4	−4	−4	−1	+1	+1	+1	+1	+1	0	0	+1	0
Means	+1	+1	+1	+1	+1	0	0	+1	+2	0	−3	−6	−6	−4	−2	+1	+1	+1	+1	+1	+2	+1	+2	+2	+2
Summer.																									
April	+3	+3	+3	+3	+2	+2	+4	+6	+4	−2	−10	−15	−13	−9	−5	−1	0	+2	+1	+1	+2	+3	+4	+4	+4
May	+5	+4	+4	+4	+4	+5	+8	+7	+3	−4	−11	−15	−13	−9	−6	−1	+2	+3	+2	+2	+3	+4	+5	+4	+5
June	+4	+4	+3	+3	+3	+5	+8	+7	+1	−6	−12	−17	−14	−11	−7	−3	+1	+3	+3	+3	+3	+4	+5	+5	+4
July	+4	+4	+4	+4	+4	+6	+9	+7	+3	−3	−10	−17	−15	−11	−9	−3	+1	+4	+3	+2	+4	+5	+5	+6	+5
August	+5	+5	+4	+4	+4	+5	+8	+7	+3	−4	−9	−14	−14	−10	−5	−1	+1	+2	+3	+1	+3	+4	+4	+4	+4
September	+2	+2	+2	+2	+2	+2	+4	+5	+3	−3	−10	−14	−11	−5	−1	+2	+3	+1	0	+1	+2	+3	+3	+3	+3
Means	+3	+3	+3	+3	+3	+4	+6	+6	+2	−4	−11	−16	−14	−10	−6	−2	+1	+2	+2	+1	+2	+3	+4	+4	+4

NOTE.—When the sign is + the V. F. is greater, and when — it is less than the mean.

P

Hourly Means of the Dip as determined at Dehra Dūn from all available days in 1914.

N 44°+

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	19·7	19·7	19·7	19·6	19·6	**19·6**	19·5	19·3	19·2	19·2	19·1	18·7	**18·7**	18·8	19·1	19·3	19·4	19·6	19·7	19·7	19·8	19·8	**19·8**	19·8	19·8	19·4
February .	20·3	20·2	20·2	**20·1**	20·1	**20·1**	**20·0**	20·0	20·0	19·8	19·6	19·2	**18·9**	19·0	19·3	19·6	19·9	20·0	20·2	20·2	20·4	20·3	**20·4**	20·3	20·3	19·9
March .	20·7	20·7	20·7	20·7	20·7	20·6	20·5	**20·8**	20·8	20·6	19·9	19·4	**19·3**	19·4	19·7	20·2	20·6	20·7	20·7	20·7	20·8	20·7	20·8	20·8	20·7	20·4
October .	25·3	25·3	25·3	25·2	25·3	25·2	25·2	25·3	**25·7**	25·6	25·2	24·5	**24·2**	24·2	24·6	25·1	25·5	25·5	25·5	25·5	25·5	25·5	25·5	25·3	25·3	25·2
November .	26·0	25·9	25·9	25·8	25·7	25·7	25·6	25·6	25·5	25·3	25·1	**24·9**	24·9	25·2	25·5	25·8	26·0	26·0	26·2	26·3	**26·3**	26·2	26·1	26·1	26·0	25·7
December .	**26·4**	26·3	26·2	26·2	26·2	26·1	26·0	25·8	25·6	25·5	25·5	**25·3**	25·5	25·8	26·0	26·2	26·3	26·3	26·3	26·2	26·3	26·3	26·3	26·3	26·4	26·0
Means .	23·1	23·0	23·0	22·9	22·9	22·9	22·8	22·8	22·8	22·7	22·4	22·0	**21·9**	22·1	22·4	22·7	23·0	23·0	23·1	23·1	**23·2**	23·1	23·2	23·1	23·1	22·8
Summer.																										
April .	22·1	22·0	22·0	21·9	21·9	21·9	21·9	22·0	**22·2**	21·8	21·3	20·7	**20·4**	20·4	20·7	21·1	21·5	21·8	21·9	22·0	22·1	22·1	22·1	22·1	22·1	21·7
May .	22·4	22·4	22·3	22·3	22·3	22·4	22·4	**22·6**	22·5	22·3	21·6	21·0	**20·8**	20·8	21·0	21·5	21·8	22·2	22·3	22·3	22·4	22·4	22·5	22·4	22·4	22·0
June .	22·9	22·8	22·8	22·8	22·9	22·9	**23·1**	23·0	22·8	22·5	21·9	21·4	**21·3**	21·4	21·7	22·1	22·6	23·0	23·0	23·0	23·0	23·0	23·0	22·9	22·9	22·6
July .	23·3	23·4	23·4	23·4	23·4	23·4	23·6	23·5	23·4	23·2	22·8	22·2	22·1	**22·1**	22·3	22·6	23·2	23·5	**23·6**	23·6	23·6	23·6	23·5	23·4	23·4	23·2
August .	24·3	24·3	24·3	24·3	24·3	24·2	24·4	**24·6**	24·5	24·3	23·9	23·4	**23·0**	23·1	23·4	23·6	23·9	24·3	24·5	24·5	24·4	24·4	24·4	24·4	24·3	24·1
September .	25·1	25·1	25·1	25·1	25·1	25·0	25·1	25·5	**25·8**	25·5	25·1	24·5	24·1	**24·1**	24·3	24·7	25·0	25·1	25·2	25·3	25·4	25·3	25·3	25·2	25·1	25·0
Means .	23·4	23·3	23·3	23·3	23·3	23·3	23·4	**23·5**	23·5	23·3	22·8	22·2	**22·0**	22·0	22·2	22·6	23·0	23·3	23·4	23·5	23·5	23·5	23·5	23·4	23·4	23·1

Diurnal Inequality of the Dip at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January . .	+0·3	+0·3	+0·3	+0·2	+0·2	+0·2	+0·1	−0·1	−0·2	−0·2	−0·3	−0·7	−0·7	−0·6	−0·3	−0·1	0	+0·2	+0·3	+0·3	+0·4	+0·4	+0·4	+0·4	+0·4
February . .	+0·4	+0·3	+0·3	+0·2	+0·2	+0·2	+0·1	+0·1	+0·1	−0·1	−0·3	−0·7	−1·0	−0·9	−0·6	−0·3	0	+0·1	+0·3	+0·3	+0·5	+0·4	+0·5	+0·4	+0·4
March . .	+0·3	+0·3	+0·3	+0·3	+0·3	+0·2	+0·1	+0·4	+0·4	+0·2	−0·5	−1·0	−1·1	−1·0	−0·7	−0·2	+0·2	+0·3	+0·3	+0·3	+0·4	+0·3	+0·4	+0·4	+0·3
October . .	+0·1	+0·1	+0·1	0	+0·1	0	0	+0·1	+0·5	+0·4	0	−0·7	−1·0	−1·0	−0·6	−0·1	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·1	+0·1
November . .	+0·3	+0·2	+0·2	+0·1	0	0	−0·1	−0·1	−0·2	−0·4	−0·6	−0·8	−0·8	−0·5	−0·2	+0·1	+0·3	+0·3	+0·5	+0·6	+0·6	+0·5	+0·4	+0·4	+0·3
December . .	+0·4	+0·3	+0·2	+0·2	+0·2	+0·1	0	−0·2	−0·4	−0·5	−0·5	−0·7	−0·5	−0·2	0	+0·2	+0·3	+0·3	+0·3	+0·2	+0·3	+0·3	+0·3	+0·3	+0·4
Means .	+0·3	+0·2	+0·2	+0·1	+0·1	+0·1	0	0	0	−0·1	−0·4	−0·8	−0·9	−0·7	−0·4	−0·1	+0·2	+0·2	+0·3	+0·3	+0·4	+0·3	+0·4	+0·3	+0·3
Summer.																									
April . . .	+0·4	+0·3	+0·3	+0·2	+0·2	+0·2	+0·2	+0·3	+0·5	+0·1	−0·4	−1·0	−1·3	−1·3	−1·0	−0·6	−0·2	+0·1	+0·2	+0·3	+0·4	+0·4	+0·4	+0·4	+0·4
May . . .	+0·4	+0·4	+0·3	+0·3	+0·3	+0·4	+0·4	+0·6	+0·5	+0·3	−0·4	−1·0	−1·2	−1·2	−1·0	−0·5	−0·2	+0·2	+0·3	+0·3	+0·4	+0·4	+0·5	+0·4	+0·4
June . . .	+0·3	+0·2	+0·2	+0·2	+0·3	+0·3	+0·5	+0·4	+0·2	−0·1	−0·7	−1·2	−1·3	−1·2	−0·9	−0·5	0	+0·4	+0·4	+0·4	+0·4	+0·4	+0·4	+0·3	+0·3
July . . .	+0·1	+0·2	+0·2	+0·2	+0·2	+0·2	+0·4	+0·3	+0·2	0	−0·4	−1·0	−1·1	−1·1	−0·9	−0·6	0	+0·3	+0·4	+0·4	+0·4	+0·4	+0·3	+0·2	+0·2
August . .	+0·2	+0·2	+0·2	+0·2	+0·2	+0·1	+0·3	+0·5	+0·4	+0·2	−0·2	−0·7	−1·1	−1·0	−0·7	−0·5	−0·2	+0·2	+0·4	+0·4	+0·3	+0·3	+0·3	+0·3	+0·2
September . .	+0·1	+0·1	+0·1	+0·1	+0·1	0	+0·1	+0·5	+0·8	+0·5	+0·1	−0·5	−0·9	−0·9	−0·7	−0·3	0	+0·1	+0·2	+0·3	+0·4	+0·3	+0·3	+0·2	+0·1
Means .	+0·3	+0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·4	+0·4	+0·2	−0·3	−0·9	−1·1	−1·1	−0·9	−0·5	−0·1	+0·2	+0·3	+0·4	+0·4	+0·4	+0·4	+0·3	+0·3

Note.—When the sign is + the Dip is more, and when − it is less than the mean.

D.—*Tables of results at Barrackpore.*

Hourly Means of the Declination as determined at Barrackpore from all available days in 1914.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
	E 0°+												Winter.													
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	34·6	34·6	34·5	34·4	34·2	34·2	33·9	33·7	34·1	34·7	34·8	34·2	34·2	34·6	35·2	35·4	35·4	34·9	34·6	34·6	34·6	34·6	34·6	34·6	34·6	34·6
February .	34·1	34·2	34·2	34·2	34·1	34·1	33·9	33·9	34·0	33·9	33·7	33·3	33·3	34·0	34·6	35·1	35·2	34·7	34·1	34·2	34·2	34·1	34·1	34·1	34·1	34·1
March .	33·9	33·9	33·9	33·8	33·8	33·8	33·7	34·2	35·1	35·4	35·2	33·9	32·8	32·1	32·4	33·2	34·0	34·1	33·9	33·8	33·8	33·8	33·8	33·9	33·9	33·8
October .	30·7	30·7	30·6	30·6	30·5	30·5	30·6	31·6	32·7	32·6	31·4	29·8	29·0	29·0	30·0	30·8	31·3	30·9	30·6	30·6	30·6	30·6	30·6	30·6	30·7	30·7
November .	30·3	30·3	30·2	30·1	30·0	29·8	29·7	29·8	30·6	30·8	30·6	29·9	29·7	30·0	30·2	30·4	30·6	30·5	30·4	30·4	30·3	30·2	30·2	30·2	30·3	30·2
December .	29·7	29·8	29·6	29·5	29·3	29·2	28·9	28·6	29·2	30·2	30·8	30·4	29·8	29·4	29·4	29·4	29·6	29·8	29·8	29·8	29·7	29·7	29·7	29·7	29·7	29·6
Means .	32·2	32·3	32·2	32·1	32·0	31·9	31·8	32·0	32·6	32·9	32·8	31·9	31·5	31·5	32·0	32·4	32·7	32·5	32·2	32·2	32·2	32·2	32·2	32·2	32·2	32·2
													Summer.													
April .	33·8	33·9	33·8	33·8	33·7	33·6	33·8	34·8	35·5	35·3	34·0	32·4	31·4	31·1	31·7	32·5	33·2	33·5	33·5	33·2	33·2	33·2	33·5	33·7	33·8	33·4
May .	33·0	33·1	33·2	33·1	33·1	33·1	34·1	35·1	35·4	34·5	32·9	31·3	30·5	30·4	30·9	31·6	32·5	33·1	33·0	32·7	32·6	32·6	32·8	32·8	33·0	32·8
June .	32·7	32·9	32·9	32·9	32·9	33·0	34·1	35·0	35·0	34·2	32·8	31·2	30·2	30·0	30·4	31·1	31·8	32·2	32·5	32·1	32·0	32·0	32·2	32·4	32·6	32·4
July .	32·0	32·2	32·4	32·5	32·4	32·6	33·8	34·7	34·7	33·8	32·4	30·8	29·8	29·7	29·8	30·3	31·2	32·0	32·0	31·6	31·7	31·8	31·9	31·9	32·0	32·0
August .	31·5	31·6	31·6	31·7	31·9	32·1	33·4	34·6	34·7	33·3	31·3	29·4	28·6	28·7	29·5	30·4	31·4	32·1	31·9	31·2	31·1	31·2	31·2	31·4	31·5	31·3
September	31·0	31·1	31·1	31·3	31·4	31·6	32·6	33·9	34·2	32·8	30·6	28·8	27·9	28·3	29·3	30·6	31·5	31·7	31·0	30·8	30·9	30·9	31·0	30·9	31·0	31·1
Means .	32·3	32·5	32·5	32·6	32·6	32·7	33·6	34·7	34·9	34·0	32·3	30·7	29·7	29·7	30·3	31·1	31·9	32·4	32·3	31·9	31·9	32·0	32·1	32·2	32·3	32·2

Diurnal Inequality of the Declination at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	0	0	−0·1	−0·2	−0·4	−0·4	−0·7	−0·9	−0·5	+0·1	+0·2	−0·4	−0·4	0	+0·6	+0·8	+0·8	+0·3	0	0	0	0	0	0	0
February	0	+0·1	+0·1	+0·1	0	0	−0·2	−0·2	−0·1	−0·2	−0·4	−0·8	−0·8	−0·1	+0·5	+1·0	+1·1	+0·6	0	+0·1	+0·1	0	0	0	0
March	+0·1	+0·1	+0·1	0	0	0	−0·1	+0·4	+1·3	+1·6	+1·4	+0·1	−1·0	−1·7	−1·4	−0·6	+0·2	+0·3	+0·1	0	0	0	0	+0·1	+0·1
October	0	0	−0·1	−0·1	−0·2	−0·2	−0·1	+0·9	+2·0	+1·9	+0·7	−0·9	−1·7	−1·7	−0·7	+0·1	+0·6	+0·2	−0·1	−0·1	−0·1	−0·1	−0·1	−0·1	0
November	+0·1	+0·1	0	−0·1	−0·2	−0·4	−0·5	−0·4	+0·4	+0·6	+0·4	−0·3	−0·5	−0·2	0	+0·2	+0·4	+0·3	+0·2	+0·2	+0·1	0	0	0	+0·1
December	+0·1	+0·2	0	−0·1	−0·3	−0·4	−0·7	−1·0	−0·4	+0·6	+1·2	+0·8	+0·2	−0·2	−0·2	−0·2	0	+0·2	+0·2	+0·2	+0·1	+0·1	+0·1	+0·1	+0·1
Means	0	+0·1	0	−0·1	−0·2	−0·3	−0·4	−0·2	+0·4	+0·7	+0·6	−0·3	−0·7	−0·7	−0·2	+0·2	+0·5	+0·3	0	0	0	0	0	0	0
Summer.																									
April	+0·4	+0·5	+0·4	+0·4	+0·3	+0·2	+0·4	+1·4	+2·1	+1·9	+0·6	−1·0	−2·0	−2·3	−1·7	−0·9	−0·2	+0·1	+0·1	−0·2	−0·2	−0·2	+0·1	+0·3	+0·4
May	+0·2	+0·3	+0·4	+0·3	+0·3	+0·3	+1·3	+2·3	+2·6	+1·7	+0·1	−1·5	−2·3	−2·4	−1·9	−1·2	−0·3	+0·3	+0·2	−0·1	−0·2	−0·2	0	0	+0·2
June	+0·3	+0·5	+0·5	+0·5	+0·5	+0·6	+1·7	+2·6	+2·6	+1·8	+0·4	−1·2	−2·2	−2·4	−2·0	−1·3	−0·6	−0·2	+0·1	−0·3	−0·4	−0·4	−0·2	0	+0·2
July	0	+0·2	+0·4	+0·5	+0·4	+0·6	+1·8	+2·7	+2·7	+1·8	+0·4	−1·2	−2·2	−2·3	−2·2	−1·7	−0·8	0	0	−0·4	−0·3	−0·2	−0·1	−0·1	0
August	0	+0·1	+0·1	+0·2	+0·4	+0·6	+1·9	+3·1	+3·2	+1·8	−0·2	−2·1	−2·9	−2·8	−2·0	−1·1	−0·1	+0·6	+0·4	−0·3	−0·4	−0·3	−0·3	−0·1	0
September	−0·1	0	0	+0·2	+0·3	+0·5	+1·5	+2·8	+3·1	+1·7	−0·5	−2·3	−3·2	−2·8	−1·8	−0·5	+0·4	+0·6	−0·1	−0·3	−0·2	−0·2	−0·1	−0·2	−0·1
Means	+0·1	+0·3	+0·3	+0·4	+0·4	+0·5	+1·4	+2·5	+2·7	+1·8	+0·1	−1·5	−2·5	−2·5	−1·9	−1·1	−0·3	+0·2	+0·1	−0·3	−0·3	−0·2	−0·1	0	+0·1

NOTE.—When the sign is + the magnet points to the East, and when — to the West of the mean position.

Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Barrackpore from all available days in 1914.

·37000 C. G. S. +

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	386	387	388	389	391	392	394	398	404	409	411	414	413	409	406	401	396	392	390	388	386	385	385	385	386	396
February .	390	392	393	395	395	396	397	399	402	407	413	419	422	420	414	407	402	396	395	393	391	388	388	389	390	400
March .	390	392	392	392	394	394	395	396	401	408	417	422	423	418	411	404	397	393	392	390	389	389	389	388	389	399
October .	396	395	397	397	399	400	401	402	400	401	407	416	423	421	412	404	397	395	395	393	393	394	394	396	398	401
November .	395	397	397	398	400	402	403	407	413	417	421	426	424	417	408	402	399	397	395	393	390	390	393	394	396	403
December .	402	401	402	404	405	407	408	413	419	423	425	428	423	417	412	407	406	405	404	404	403	403	401	401	402	409
Means .	393	394	395	396	397	399	400	403	407	411	416	421	421	417	411	404	400	396	395	394	392	392	392	392	394	401
Summer.																										
April .	386	387	388	389	391	393	394	394	396	403	412	419	421	421	416	409	401	395	391	388	386	387	386	387	386	397
May .	401	403	403	405	405	405	407	408	410	415	425	431	433	433	427	419	411	406	403	402	401	400	401	401	401	411
June .	410	411	413	412	412	412	414	418	422	426	434	441	440	439	432	425	415	410	408	409	408	407	408	409	410	418
July .	400	399	399	401	401	401	403	406	410	412	417	421	422	422	419	413	405	397	396	395	395	395	397	398	400	405
August .	393	395	396	395	397	397	400	402	402	405	411	414	419	419	413	407	403	396	390	390	390	391	393	394	393	401
September .	396	399	398	399	400	401	402	398	393	395	402	408	412	414	413	408	402	398	396	393	392	392	394	394	396	400
Means .	398	399	400	400	401	402	403	404	406	409	417	422	425	425	420	414	406	400	397	396	395	395	397	397	398	405

Diu. nal Inequality of the Horizontal Force at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	−10	−9	−8	−7	−5	−4	−2	+2	+8	+13	+15	+18	+17	+13	+10	+5	0	−4	−6	−8	−10	−11	−11	−11	−10
February	−10	−8	−7	−5	−5	−4	−3	−1	+2	+7	+13	+19	+22	+20	+14	+7	+2	−4	−5	−7	−9	−12	−12	−11	−10
March	−9	−7	−7	−7	−5	−5	−4	−3	+2	+9	+18	+23	+24	+19	+12	+5	−2	−6	−7	−9	−10	−10	−10	−11	−10
October	−5	−6	−4	−4	−2	−1	0	+1	−1	0	+6	+15	+22	+20	+11	+3	−4	−6	−6	−8	−8	−7	−7	−5	−3
November	−8	−6	−6	−5	−3	−1	0	+4	+10	+14	+18	+23	+21	+14	+5	−1	−4	−6	−8	−10	−13	−13	−10	−9	−7
December	−7	−8	−7	−5	−4	−2	−1	+4	+10	+14	+16	+19	+14	+8	+3	−2	−3	−4	−5	−5	−6	−6	−8	−8	−7
Means	−8	−7	−6	−5	−4	−2	−1	+2	+6	+10	+15	+20	+20	+16	+10	+3	−1	−5	−6	−7	−9	−9	−9	−9	−7
Summer.																									
April	−11	−10	−9	−8	−6	−4	−3	−3	−1	+6	+15	+22	+24	+24	+19	+12	+4	−2	−6	−9	−11	−10	−11	−10	−11
May	−10	−8	−8	−6	−6	−6	−4	−3	−1	+4	+14	+20	+22	+22	+16	+8	0	−5	−8	−9	−10	−11	−10	−10	−10
June	−8	−7	−5	−6	−6	−6	−4	0	+4	+8	+16	+23	+22	+21	+14	+7	−3	−8	−10	−9	−10	−11	−10	−9	−8
July	−5	−6	−6	−4	−4	−4	−2	+1	+5	+7	+12	+16	+17	+17	+14	+8	0	−8	−9	−10	−10	−10	−8	−7	−5
August	−8	−6	−5	−6	−4	−4	−1	+1	+1	+4	+10	+13	+18	+18	+12	+6	+2	−5	−11	−11	−11	−10	−8	−7	−8
September	−4	−1	−2	−1	0	+1	+2	−2	−7	−5	+2	+8	+12	+14	+13	+8	+2	−2	−4	−7	−8	−8	−6	−6	−4
Means	−7	−6	−5	−5	−4	−3	−2	−1	+1	+4	+12	+17	+20	+20	+15	+9	+1	−5	−8	−9	−10	−10	−8	−8	−7

NOTE.—When the sign is + the H. F. is greater, and when − it is less than the mean.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Barrackpore from all available days in 1914.

·22000 C. G. S.+

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	422	423	423	424	424	425	426	427	**427**	425	420	419	**419**	421	421	422	422	422	423	422	422	422	423	423	423	423
February .	431	431	431	431	432	432	433	**434**	433	431	427	425	**425**	426	427	428	429	429	430	430	431	431	431	432	432	430
March .	435	436	436	437	437	437	437	**438**	437	433	429	424	**422**	423	427	430	432	432	434	434	435	435	435	435	435	433
October .	479	479	479	479	479	480	480	**482**	480	475	470	468	**467**	469	472	474	475	476	478	478	479	479	479	478	478	476
November .	491	491	491	491	491	492	493	**494**	493	490	486	483	**482**	483	484	485	488	489	490	491	491	491	491	491	491	489
December .	491	490	491	491	492	493	493	494	**495**	494	490	486	485	**483**	483	485	487	489	490	490	490	490	490	490	490	490
Means .	458	458	459	459	459	460	460	**462**	461	458	454	451	**450**	451	452	454	456	456	458	458	458	458	458	458	458	457
Summer.																										
April .	445	445	446	446	446	447	**448**	447	444	437	431	**427**	429	433	437	440	442	443	444	444	445	446	445	446	446	442
May .	452	452	452	452	453	453	**455**	452	450	445	442	**440**	442	445	446	449	449	449	450	451	452	452	453	452	452	450
June .	466	465	465	465	466	467	**468**	466	463	459	458	**457**	459	461	462	463	464	465	465	466	466	467	467	466	466	464
July .	465	464	464	464	464	465	**466**	464	461	458	455	**453**	454	457	457	459	460	461	463	463	465	465	466	465	465	462
August .	469	469	469	469	469	469	**471**	469	465	461	459	**458**	460	462	464	466	467	467	467	469	470	470	470	469	469	467
September .	478	478	478	478	478	478	**480**	479	475	471	467	**465**	467	470	473	475	475	475	476	477	477	478	479	478	478	475
Means .	463	462	462	462	463	463	**465**	463	460	455	452	**450**	452	455	457	459	460	460	461	462	463	463	463	463	463	460

Diurnal Inequality of the Vertical Force at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January . .	−1	0	0	+1	+1	+2	+3	+4	+4	+2	−3	−4	−4	−2	−2	−1	−1	−1	0	−1	−1	−1	0	0	0
February . .	+1	+1	+1	+1	+2	+2	+3	+4	+3	+1	−3	−5	−5	−4	−3	−2	−1	−1	0	0	+1	+1	+1	+2	+2
March . .	+2	+3	+3	+4	+4	+4	+4	+5	+4	0	−4	−9	−11	−10	−6	−3	−1	−1	+1	+1	+2	+2	+2	+2	+2
October . .	+3	+3	+3	+3	+3	+4	+4	+6	+4	−1	−6	−8	−9	−7	−4	−2	−1	0	+2	+2	+3	+3	+3	+2	+2
November . .	+2	+2	+2	+2	+2	+3	+4	+5	+4	+1	−3	−6	−7	−6	−5	−4	−1	0	+1	+2	+2	+2	+2	+2	+2
December . .	+1	0	+1	+1	+2	+3	+3	+4	+5	+4	−0	−4	−5	−7	−7	−5	−3	−1	0	0	0	0	0	0	0
Means . .	+1	+1	+2	+2	+2	+3	+3	+5	+4	+1	−3	−6	−7	−6	−5	−3	−1	−1	+1	+1	+1	+1	+1	+1	+1
Summer.																									
April . .	+3	+3	+4	+4	+4	+5	+6	+5	+2	−5	−11	−15	−13	−9	−5	−2	0	+1	+2	+2	+3	+4	+3	+4	+4
May . .	+2	+2	+2	+2	+3	+3	+5	+2	0	−5	−8	−10	−8	−5	−4	−1	−1	−1	0	+1	+2	+2	+3	+2	+2
June . .	+2	+1	+1	+1	+2	+3	+4	+2	−1	−5	−6	−7	−5	−3	−2	−1	0	+1	+1	+2	+2	+3	+3	+2	+2
July . .	+3	+2	+2	+2	+2	+3	+4	+2	−1	−4	−7	−9	−8	−5	−5	−3	−2	−1	+1	+1	+3	+3	+4	+3	+3
August . .	+2	+2	+2	+2	+2	+2	+4	+2	−2	−6	−8	−9	−7	−5	−3	−1	0	0	0	+2	+3	+3	+3	+2	+2
September . .	+3	+3	+3	+3	+3	+3	+5	+4	0	−4	−8	−10	−8	−5	−2	0	0	0	+1	+2	+2	+3	+4	+3	+3
Means . .	+3	+2	+2	+2	+3	+3	+5	+3	0	−5	−8	−10	−8	−5	−3	−1	0	0	+1	+2	+3	+3	+3	+3	+3

NOTE.—When the sign is + the V. F. is greater, and when − it is less than the mean.

Hourly Means of the Dip as determined at Barrackpore from all available days in 1914.

N 30°+

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	57·2	57·2	57·2	57·2	57·1	57·1	57·1	57·0	56·8	56·4	56·0	55·9	55·9	56·2	56·3	56·6	56·7	56·9	57·1	57·1	57·2	57·2	57·3	57·3	57·2	56·8
February	57·6	57·6	57·5	57·4	57·5	57·4	57·5	57·5	57·3	57·0	56·4	56·0	55·9	56·1	56·4	56·7	57·0	57·2	57·4	57·4	57·6	57·7	57·7	57·8	57·7	57·2
March	57·9	57·9	57·9	57·9	57·9	57·9	57·8	57·8	57·6	57·1	56·4	55·8	55·7	55·9	56·5	57·0	57·4	57·6	57·8	57·8	58·0	58·0	58·0	58·0	58·0	57·4
October	60·6	60·7	60·6	60·6	60·5	60·6	60·5	60·6	60·6	60·2	59·6	59·1	58·7	58·9	59·5	60·0	60·3	60·5	60·6	60·7	60·8	60·7	60·7	60·6	60·5	60·3
November	61·5	61·4	61·4	61·4	61·3	61·3	61·3	61·2	60·9	60·5	60·1	59·7	59·7	60·0	60·5	60·8	61·1	61·3	61·4	61·6	61·7	61·7	61·6	61·5	61·4	61·0
December	61·2	61·2	61·2	61·1	61·1	61·1	61·1	61·0	60·8	60·6	60·2	59·8	59·9	60·0	60·2	60·6	60·8	60·9	61·0	61·0	61·1	61·1	61·2	61·2	61·1	60·8
Means	59·3	59·3	59·3	59·3	59·2	59·2	59·2	59·2	59·0	58·6	58·1	57·7	57·6	57·9	58·2	58·6	58·9	59·1	59·2	59·3	59·4	59·4	59·4	59·4	59·3	58·9
Summer.																										
April	58·7	58·7	58·7	58·7	58·6	58·6	58·6	58·6	58·2	57·5	56·7	56·2	56·2	56·5	57·0	57·4	57·9	58·2	58·5	58·6	58·7	58·8	58·7	58·8	58·8	58·0
May	58·6	58·5	58·5	58·5	58·5	58·5	58·6	58·4	58·1	57·6	57·0	56·6	56·6	56·9	57·1	57·7	58·0	58·2	58·4	58·5	58·6	58·7	58·7	58·6	58·6	58·1
June	59·2	59·1	59·0	59·1	59·1	59·2	59·2	58·9	58·5	58·1	57·7	57·3	57·5	57·7	58·0	58·4	58·8	59·1	59·2	59·2	59·3	59·4	59·4	59·2	59·2	58·7
July	59·5	59·5	59·5	59·4	59·4	59·5	59·5	59·2	58·8	58·6	58·1	57·8	57·9	58·1	58·2	58·6	59·0	59·4	59·5	59·6	59·8	59·8	59·7	59·6	59·5	59·1
August	60·1	60·0	59·9	60·0	59·9	59·9	59·9	59·7	59·5	59·1	58·7	58·5	58·4	58·6	58·9	59·3	59·5	59·8	60·1	60·2	60·2	60·2	60·1	60·0	60·1	59·6
September	60·6	60·4	60·5	60·4	60·4	60·4	60·5	60·6	60·5	60·1	59·6	59·2	59·2	59·3	59·5	59·9	60·1	60·3	60·4	60·6	60·7	60·7	60·7	60·7	60·6	60·2
Means	59·5	59·4	59·4	59·4	59·3	59·4	59·4	59·2	58·9	58·5	58·0	57·6	57·6	57·9	58·1	58·6	58·9	59·2	59·4	59·5	59·6	59·6	59·6	59·5	59·5	59·0

Diurnal Inequality of the Dip at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January . . .	+0·4	+0·4	+0·4	+0·4	+0·3	+0·3	+0·3	+0·2	0	−0·4	−0·8	−0·9	−0·9	−0·6	−0·5	−0·2	−0·1	+0·1	+0·3	+0·3	+0·4	+0·4	+0·5	+0·5	+0·4
February . .	+0·4	+0·4	+0·3	+0·2	+0·3	+0·2	+0·3	+0·3	+0·1	−0·2	−0·8	−1·2	−1·3	−1·1	−0·8	−0·5	−0·2	0	+0·2	+0·2	+0·4	+0·5	+0·5	+0·6	+0·5
March . . .	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·4	+0·4	+0·2	−0·3	−1·0	−1·6	−1·7	−1·5	−0·9	−0·4	0	+0·2	+0·4	+0·4	+0·6	+0·6	+0·6	+0·6	+0·6
October . . .	+0·3	+0·4	+0·3	+0·3	+0·2	+0·3	+0·2	+0·3	+0·3	−0·1	−0·7	−1·2	−1·6	−1·4	−0·8	−0·3	0	+0·2	+0·3	+0·4	+0·5	+0·4	+0·4	+0·3	+0·2
November . .	+0·5	+0·4	+0·4	+0·4	+0·3	+0·3	+0·3	+0·2	−0·1	−0·5	−0·9	−1·3	−1·3	−1·0	−0·5	−0·2	+0·1	+0·3	+0·4	+0·6	+0·7	+0·7	+0·6	+0·5	+0·4
December . .	+0·4	+0·4	+0·4	+0·3	+0·3	+0·3	+0·3	+0·2	0	−0·2	−0·6	−1·0	−0·9	−0·8	−0·6	−0·2	0	+0·1	+0·2	+0·2	+0·3	+0·3	+0·4	+0·4	+0·3
Means . .	+0·4	+0·4	+0·4	+0·4	+0·3	+0·3	+0·3	+0·3	+0·1	−0·3	−0·8	−1·2	−1·3	−1·0	−0·7	−0·3	0	+0·2	+0·3	+0·4	+0·5	+0·5	+0·5	+0·5	+0·4
Summer.																									
April . . .	+0·7	+0·7	+0·7	+0·7	+0·6	+0·6	+0·6	+0·6	+0·2	−0·5	−1·3	−1·8	−1·8	−1·5	−1·0	−0·6	−0·1	+0·2	+0·5	+0·6	+0·7	+0·8	+0·7	+0·8	+0·8
May . . .	+0·5	+0·4	+0·4	+0·4	+0·4	+0·4	+0·5	+0·3	0	−0·5	−1·1	−1·5	−1·5	−1·2	−1·0	−0·4	−0·1	+0·1	+0·3	+0·4	+0·5	+0·6	+0·6	+0·5	+0·5
June . . .	+0·5	+0·4	+0·3	+0·4	+0·4	+0·5	+0·5	+0·2	−0·2	−0·6	−1·0	−1·4	−1·2	−1·0	−0·7	−0·3	+0·1	+0·4	+0·5	+0·5	+0·6	+0·7	+0·7	+0·5	+0·5
July . . .	+0·4	+0·4	+0·4	+0·3	+0·3	+0·4	+0·4	+0·1	−0·3	−0·5	−1·0	−1·3	−1·2	−1·0	−0·9	−0·5	−0·1	+0·3	+0·4	+0·5	+0·7	+0·7	+0·6	+0·5	+0·4
August . . .	+0·5	+0·4	+0·3	+0·4	+0·3	+0·3	+0·3	+0·1	−0·1	−0·5	−0·9	−1·1	−1·2	−1·0	−0·7	−0·3	−0·1	+0·2	+0·5	+0·6	+0·6	+0·6	+0·5	+0·4	+0·5
September . .	+0·4	+0·2	+0·3	+0·2	+0·2	+0·2	+0·3	+0·4	+0·3	−0·1	−0·6	−1·0	−1·0	−0·9	−0·7	−0·3	−0·1	+0·1	+0·2	+0·4	+0·5	+0·5	+0·5	+0·5	+0·4
Means . .	+0·5	+0·4	+0·4	+0·4	+0·3	+0·4	+0·4	+0·2	−0·1	−0·5	−1·0	−1·4	−1·4	−1·1	−0·9	−0·4	−0·1	+0·2	+0·4	+0·5	+0·6	+0·6	+0·6	+0·5	+0·5

NOTE.—When the sign is + the Dip is more, and when — it is less than the mean.

E.—*Tables of results at Toungoo.*

Hourly Means of the Declination as determined at Toungoo from all available days in 1914.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
	E 0° +												Winter.													
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	5·0	5·1	5·0	4·8	4·7	4·6	4·4	4·1	4·4	5·0	5·2	5·0	4·8	5·2	5·6	5·8	5·8	5·4	5·2	5·2	5·1	5·1	5·0	5·0	5·0	5·0
February .	4·4	4·5	4·5	4·5	4·4	4·3	4·2	4·3	4·2	4·0	3·7	3·6	3·7	4·5	5·1	5·4	5·4	5·1	4·5	4·6	4·5	4·4	4·3	4·4	4·4	4·4
March .	4·1	4·2	4·2	4·2	4·0	3·9	3·9	4·4	5·1	5·3	5·1	4·3	3·4	2·9	2·9	3·6	4·2	4·3	4·2	4·2	4·1	4·0	4·0	4·0	4·1	4·1
October .	1·1	1·1	1·0	1·0	0·9	0·9	1·1	2·0	2·7	2·6	1·6	0·3	—0·4	—0·2	0·4	1·1	1·5	1·4	1·1	1·1	1·0	1·0	1·0	1·0	1·1	1·1
November .	0·7	0·7	0·5	0·4	0·3	0·2	0 1	0·2	0·9	1·2	1·0	0·7	0·5	0·8	0·7	0·8	1·1	1·0	0·9	0·9	0·8	0·6	0·6	0·6	0·6	0·7
December .	0·1	0·1	0·1	0·0	—0·1	—0·3	—0·6	—0·9	—0·3	0·5	1·1	1·0	0·6	0·2	—0·1	—0·1	0·2	0·3	0·2	0·2	0·2	0·1	0·1	0·1	0·1	0·1
Means .	2·6	2·6	2·6	2·5	2·4	2·3	2·2	2·4	2·8	3·1	3·0	2·5	2·1	2·2	2·4	2·8	3·0	2·9	2·7	2·7	2·6	2·5	2·5	2·5	2·6	2·6
													Summer.													
April .	3·8	3·9	3·9	3·9	3·8	3·7	4·1	4·8	5·1	4·7	3·9	2·8	1·9	1·8	2·1	2·9	3·4	3·8	3·6	3·5	3·4	3·4	3·5	3·7	3·8	3·6
May .	3·2	3·4	3·4	3·4	3·3	3·3	4·3	5·1	5·4	4·7	3·5	2·3	1·4	1·3	1·7	2·2	2·9	3·3	3·3	3·1	3·0	3·0	3·0	3·1	3·2	3·2
June .	2·9	3·1	3·2	3·2	3·2	3·3	4·3	5·1	5·3	4·4	3·5	2·5	1·5	1·3	1·4	1·7	2·3	2·5	2·8	2·5	2·5	2·4	2·5	2·6	2·9	2·9
July .	2·3	2·5	2·7	2·7	2·8	3·0	4·0	4·7	4·8	4·1	2·9	1·9	1·1	0·8	0·8	1·1	1·8	2·3	2·4	2·1	2·0	2·1	2·2	2·2	2·3	2·5
August .	1·8	1·9	2·0	2·0	2·1	2·4	3·7	4·8	4·9	3·7	2·0	0·6	0·0	0·1	0·5	1·2	2·0	2·5	2·2	1·8	1·7	1·6	1·5	1·7	1·8	2·0
September .	1·4	1·5	1·5	1·5	1·7	1·9	2·9	4·3	4·4	3·2	1·3	—0·1	—1·0	—0·9	—0·2	0·9	1·9	2·1	1·5	1·3	1·3	1·3	1·3	1·3	1·4	1·5
Means .	2·6	2·7	2·8	2·8	2·8	2·9	3·9	4·8	5·0	4·1	2·9	1·7	0·8	0·7	1·1	1·7	2·4	2·8	2·6	2·4	2·3	2·3	2·3	2·4	2·6	2·6

Diurnal Inequality of the Declination at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January . .	0	+0·1	0	−0·2	−0·3	−0·4	−0·6	−0·9	−0·6	0	+0·2	0	−0·2	+0·2	+0·6	+0·8	+0·8	+0·4	+0·2	+0·2	+0·1	+0·1	0	0	0
February . .	0	+0·1	+0·1	+0·1	0	−0·1	−0·2	−0·1	−0·2	−0·4	−0·7	−0·8	−0·7	+0·1	+0·7	+1·0	+1·0	+0·7	+0·1	+0·2	+0·1	0	−0·1	0	0
March . . .	0	+0·1	+0·1	+0·1	−0·1	−0·2	−0·2	+0·3	+1·0	+1·2	+1·0	+0·2	−0·7	−1·2	−1·2	−0·5	+0·1	+0·2	+0·1	+0·1	0	−0·1	−0·1	−0·1	0
October . .	0	0	−0·1	−0·1	−0·2	−0·2	0	+0·9	+1·6	+1·5	+0·5	−0·8	−1·5	−1·3	−0·7	0	+0·4	+0·3	0	0	−0·1	−0·1	−0·1	−0·1	0
November . .	0	0	−0·2	−0·3	−0·4	−0·5	−0·6	−0·5	+0·2	+0·5	+0·3	0	−0·2	+0·1	0	+0·1	+0·4	+0·3	+0·2	+0·2	+0·1	−0·1	−0·1	−0·1	−0·1
December . .	0	0	0	−0·1	−0·2	−0·4	−0·7	−1·0	−0·4	+0·4	+1·0	+0·9	+0·5	+0·1	−0·2	−0·2	+0·1	+0·2	+0·1	+0·1	+0·1	0	0	0	0
Means . .	0	0	0	−0·1	−0·2	−0·3	−0·4	−0·2	+0·2	+0·5	+0·4	−0·1	−0·5	−0·4	−0·2	+0·2	+0·4	+0·3	+0·1	+0·1	0	−0·1	−0·1	−0·1	0
Summer.																									
April . . .	+0·2	+0·3	+0·3	+0·3	+0·2	+0·1	+0·5	+1·2	+1·5	+1·1	+0·3	−0·8	−1·7	−1·8	−1·5	−0·7	−0·2	+0·2	0	−0·1	−0·2	−0·2	−0·1	+0·1	+0·2
May . . .	0	+0·2	+0·2	+0·2	+0·1	+0·1	+1·1	+1·9	+2·2	+1·5	+0·3	−0·9	−1·8	−1·9	−1·5	−1·0	−0·3	+0·1	+0·1	−0·1	−0·2	−0·2	−0·2	−0·1	0
June . . .	0	+0·2	+0·3	+0·3	+0·3	+0·4	+1·4	+2·2	+2·4	+1·5	+0·6	−0·4	−1·4	−1·6	−1·5	−1·2	−0·6	−0·4	−0·1	−0·4	−0·4	−0·5	−0·4	−0·3	0
July . . .	−0·2	0	+0·2	+0·2	+0·3	+0·5	+1·5	+2·2	+2·3	+1·6	+0·4	−0·6	−1·4	−1·7	−1·7	−1·4	−0·7	−0·2	−0·1	−0·4	−0·5	−0·4	−0·3	−0·3	−0·2
August . . .	−0·2	−0·1	0	0	+0·1	+0·4	+1·7	+2·8	+2·9	+1·7	0	−1·4	−2·0	−1·9	−1·5	−0·8	0	+0·5	+0·2	−0·2	−0·3	−0·4	−0·5	−0·3	−0·2
September . .	−0·1	0	0	0	+0·2	+0·4	+1·4	+2·8	+2·9	+1·7	−0·2	−1·6	−2·5	−2·4	−1·7	−0·6	+0·4	+0·6	0	−0·2	−0·2	−0·2	−0·2	−0·2	−0·1
Means . .	0	+0·1	+0·2	+0·2	+0·2	+0·3	+1·3	+2·2	+2·4	+1·5	+0·3	−0·9	−1·8	−1·9	−1·5	−0·9	−0·2	+0·2	0	−0·2	−0·3	−0·3	−0·3	−0·2	0

NOTE.—When the sign is + the magnet points to the East, and when — to the West of the mean position.

Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Toungoo from all available days in 1914.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
·38000 C. G. S. +													Winter.													
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	971	972	973	973	974	975	976	980	988	993	998	**999**	999	994	988	983	977	973	973	972	971	**970**	971	971	971	980
February .	971	972	973	974	975	975	976	978	983	990	998	1003	**1005**	1000	991	984	979	975	974	973	971	**968**	969	969	971	980
March .	968	969	969	969	970	971	970	972	978	988	999	**1006**	1005	998	988	978	971	968	968	968	**967**	967	968	966	968	977
October	981	981	981	981	983	983	983	985	986	992	1002	1011	**1013**	1006	995	985	980	**977**	979	979	979	979	981	982	983	987
November .	979	981	981	981	982	984	986	990	997	1005	1009	**1012**	1010	1001	992	985	981	980	980	978	**975**	976	978	980	979	988
December .	987	**984**	986	987	986	989	991	997	1002	1007	1012	**1013**	1012	1006	998	991	988	986	986	986	987	987	986	985	987	993
Means .	976	977	977	978	978	980	980	983	989	996	1003	**1007**	1007	1001	992	984	979	977	977	976	975	**975**	976	976	977	984
													Summer.													
April .	967	**966**	967	968	969	970	970	972	979	991	1003	**1007**	1006	1001	993	984	976	971	968	968	966	966	968	966	967	978
May . .	975	977	977	978	978	979	980	982	987	995	1005	**1011**	1011	1009	1000	990	983	977	976	976	975	975	**975**	976	976	985
June .	976	977	977	977	977	977	978	981	988	995	1003	**1008**	1007	1005	996	986	977	**972**	972	975	975	973	974	975	975	983
July .	978	979	979	979	979	978	980	985	992	998	1004	**1006**	1005	1003	998	989	981	973	**973**	975	975	976	977	977	978	985
August .	971	972	972	972	972	973	974	977	981	989	994	997	**997**	995	988	979	974	968	**966**	968	967	970	971	970	971	977
September .	975	977	977	978	978	977	978	975	974	981	992	997	**997**	995	990	983	976	974	974	973	972	**972**	974	974	975	980
Means .	974	975	975	975	976	976	977	979	984	992	1000	**1004**	1004	1001	994	985	978	973	**972**	973	972	972	973	973	974	981

Diurnal Inequality of the Horizontal Force at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
													Winter.												
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January . .	−9	−8	−7	−7	−6	−5	−4	0	+8	+13	+18	+19	+19	+14	+8	+3	−3	−7	−7	−8	−9	−10	−9	−9	−9
February . .	−9	−8	−7	−6	−5	−5	−4	−2	+3	+10	+18	+23	+25	+20	+11	+4	−1	−5	−6	−7	−9	−12	−11	−11	−9
March . . .	−9	−8	−8	−8	−7	−6	−7	−5	+1	+11	+22	+29	+28	+21	+11	+1	−6	−9	−9	−9	−10	−10	−9	−11	−9
October . .	−6	−6	−6	−6	−4	−4	−4	−4	−1	+5	+15	+24	+26	+19	+8	−2	−7	−10	−8	−8	−8	−8	−6	−5	−4
November . .	−9	−7	−7	−7	−6	−4	−2	+2	+9	+17	+21	+24	+22	+13	+4	−3	−7	−8	−8	−10	−13	−12	−10	−8	−9
December . .	−6	−9	−7	−6	−7	−4	−2	+4	+9	+14	+19	+20	+19	+13	+5	−2	−5	−7	−7	−7	−6	−6	−7	−8	−6
Means . .	−8	−7	−7	−6	−6	−4	−4	−1	+5	+12	+19	+23	+23	+17	+8	0	−5	−7	−7	−8	−9	−9	−8	−8	−7
													Summer.												
April	−11	−12	−11	−10	−9	−8	−8	−6	+1	+13	+25	+29	+28	+23	+15	+6	−2	−7	−10	−10	−12	−12	−10	−12	−11
May . . .	−10	−8	−8	−7	−7	−6	−5	−3	+2	+10	+20	+26	+26	+24	+15	+5	−2	−8	−9	−9	−10	−10	−10	−9	−9
June . . .	−7	−6	−6	−6	−6	−6	−5	−2	+5	+12	+20	+25	+24	+22	+13	+3	−6	−11	−11	−8	−8	−10	−9	−8	−8
July . . .	−7	−6	−6	−6	−6	−7	−5	0	+7	+13	+19	+21	+20	+18	+13	+4	−4	−12	−12	−10	−10	−9	−8	−8	−7
August . .	−6	−5	−5	−5	−5	−4	−3	0	+4	+12	+17	+20	+20	+18	+11	+2	−3	−9	−11	−9	−10	−7	−6	−7	−6
September . .	−5	−3	−3	−2	−2	−3	−2	−5	−6	+1	+12	+17	+17	+15	+10	+3	−4	−6	−6	−7	−8	−8	−6	−6	−5
Means . .	−7	−6	−6	−6	−5	−5	−4	−2	+3	+11	+19	+23	+23	+20	+13	+4	−3	−8	−9	−8	−9	−9	−8	−8	−7

NOTE.—When the sign is + the H. F. is greater, and when − it is less than the mean.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Toungoo from all available days in 1914.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
·16000 C. G. S. +													Winter.													
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	624	624	624	624	624	624	623	622	622	620	616	615	616	621	623	624	623	622	623	623	624	624	624	624	624	622
February	627	627	627	627	627	627	627	626	622	618	614	613	617	622	625	627	626	624	624	626	626	626	626	627	627	624
March	617	617	618	618	617	617	618	619	615	609	604	600	599	603	609	614	615	615	615	615	616	616	617	617	618	613
October	643	643	643	643	643	644	646	647	642	632	624	622	625	633	639	641	640	639	640	641	641	642	642	643	643	639
November	646	646	646	646	646	646	646	647	646	641	637	636	637	638	638	641	643	643	644	644	645	615	646	646	646	643
December	645	645	645	645	645	644	644	643	645	644	640	636	631	632	634	637	641	642	643	644	644	644	644	645	645	642
Means	634	634	634	634	634	634	634	634	632	627	623	620	621	625	628	631	631	631	632	632	633	633	633	634	634	631
													Summer.													
April	630	630	630	630	629	629	631	631	624	616	610	609	611	617	623	627	629	629	627	628	628	629	629	630	630	625
May	631	631	631	630	630	631	634	633	627	620	616	615	617	621	626	629	631	630	629	629	629	630	631	631	631	628
June	627	627	626	626	626	627	630	628	623	617	615	613	614	619	623	625	627	627	626	625	626	626	627	627	627	624
July	629	629	629	629	629	630	632	630	626	619	615	614	615	620	622	626	628	628	627	627	627	628	628	628	629	626
August	630	630	630	630	630	631	635	634	626	616	611	613	617	622	626	630	631	631	628	628	629	630	630	630	630	627
September	632	633	633	633	633	633	638	637	627	615	608	607	612	620	628	632	633	631	628	630	631	631	632	632	632	628
Means	630	630	630	630	630	630	633	632	626	617	613	612	614	620	625	628	630	629	628	628	628	629	630	630	630	626

Diurnal Inequality of the Vertical Force at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January . .	+2	+2	+2	+2	+2	+2	+1	0	0	−2	−6	−7	−6	−1	+1	+2	+1	0	+1	+1	+2	+2	+2	+2	+2
February . .	+3	+3	+3	+3	+3	+3	+3	+2	−2	−6	−10	−11	−7	−2	+1	+3	+2	0	0	+2	+2	+2	+2	+3	+3
March . . .	+4	+4	+5	+5	+4	+4	+5	+6	+2	−4	−9	−13	−14	−10	−4	+1	+2	+2	+2	+2	+3	+3	+4	+4	+5
October . .	+4	+4	+4	+4	+4	+5	+7	+8	+3	−7	−15	−17	−14	−6	0	+2	+1	0	+1	+2	+2	+3	+3	+4	+4
November . .	+3	+3	+3	+3	+3	+3	+3	+4	+3	−2	−6	−7	−6	−5	−5	−2	0	0	+1	+1	+2	+2	+3	+3	+3
December . .	+3	+3	+3	+3	+3	+2	+2	+1	+3	+2	−2	−6	−11	−10	−8	−5	−1	0	+1	+2	+2	+2	+2	+3	+3
Means . .	+3	+3	+3	+3	+3	+3	+3	+3	+1	−4	−8	−11	−10	−6	−3	0	0	0	+1	+1	+2	+2	+2	+3	+3
Summer.																									
April . . .	+5	+5	+5	+5	+4	+4	+6	+6	−1	−9	−15	−16	−14	−8	−2	+2	+4	+4	+2	+3	+3	+4	+4	+5	+5
May . . .	+3	+3	+3	+2	+2	+3	+6	+5	−1	−8	−12	−13	−11	−7	−2	+1	+3	+2	+1	+1	+1	+2	+3	+3	+3
June . . .	+3	+3	+2	+2	+2	+3	+6	+4	−1	−7	−9	−11	−10	−5	−1	+1	+3	+3	+3	+1	+2	+2	+3	+3	+3
July . . .	+3	+3	+3	+3	+3	+4	+6	+4	0	−7	−11	−12	−11	−6	−4	0	+2	+2	+1	+1	+1	+2	+2	+2	+3
August . .	+3	+3	+3	+3	+3	+4	+8	+7	−1	−11	−16	−14	−10	−5	−1	+3	+4	+4	+1	+1	+2	+3	+3	+3	+3
September . .	+4	+5	+5	+5	+5	+5	+10	+9	−1	−13	−20	−21	−16	−8	0	+4	+5	+3	0	+2	+3	+3	+4	+4	+4
Means . .	+4	+4	+4	+4	+4	+4	+7	+6	0	−9	−13	−14	−12	−6	−1	+2	+4	+3	+2	+2	+2	+3	+4	+4	+4

NOTE.—When the sign is + the V. F. is greater, and when − it is less than the mean.

Hourly Means of the Dip as determined at Toungoo from all available days in 1914.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
													N 23° +													
													Winter.													
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	6·1	6·1	6·1	6·1	6·0	6·0	5·9	5·7	5·4	5·1	4·7	4·6	4·6	5·2	5·5	5·7	5·8	5·9	6·0	6·0	6·1	6·2	6·1	6·1	6·1	5·7
February	6·3	6·3	6·3	6·2	6·2	6·2	6·2	6·0	5·6	5·1	4·5	4·3	4·5	5·0	5·6	5·9	6·0	6·0	6·0	6·2	6·3	6·4	6·3	6·4	6·3	5·8
March	5·7	5·6	5·7	5·7	5·6	5·6	5·7	5·7	5·2	4·4	3·7	3·2	3·2	3·7	4·4	5·1	5·4	5·5	5·5	5·5	5·6	5·6	5·7	5·7	5·8	5·1
October	7·2	7·2	7·2	7·2	7·1	7·2	7·4	7·4	7·0	6·0	5·1	4·7	4·8	5·7	6·5	6·9	7·0	7·0	7·0	7·1	7·1	7·2	7·2	7·2	7·1	6·7
November	7·5	7·4	7·4	7·4	7·4	7·3	7·3	7·2	6·9	6·3	5·9	5·7	5·8	6·2	6·5	6·9	7·2	7·2	7·3	7·4	7·5	7·5	7·5	7·5	7·5	7·0
December	7·2	7·2	7·2	7·2	7·2	7·0	7·0	6·7	6·7	6·5	6·0	5·7	5·3	5·6	6·0	6·5	6·8	7·0	7·0	7·1	7·1	7·1	7·1	7·2	7·2	6·7
Means	6·7	6·6	6·7	6·6	6·6	6·6	6·6	6·5	6·1	5·6	5·0	4·7	4·7	5·2	5·8	6·2	6·4	6·4	6·5	6·6	6·6	6·7	6·7	6·7	6·7	6·2
													Summer.													
April	6·7	6·7	6·7	6·6	6·6	6·5	6·7	6·6	5·9	4·9	4·1	3·9	4·1	4·6	5·3	5·9	6·3	6·5	6·4	6·5	6·6	6·6	6·6	6·7	6·7	6·0
May	6·5	6·4	6·4	6·3	6·3	6·4	6·6	6·4	5·8	5·0	4·4	4·2	4·3	4·7	5·4	5·9	6·2	6·4	6·3	6·3	6·4	6·4	6·5	6·5	6·5	5·9
June	6·2	6·1	6·1	6·1	6·1	6·1	6·3	6·1	5·5	4·8	4·4	4·1	4·2	4·6	5·2	5·7	6·1	6·8	6·2	6·0	6·1	6·2	6·2	6·2	6·2	5·7
July	6·3	6·2	6·2	6·2	6·2	6·3	6·4	6·1	5·6	4·9	4·4	4·3	4·4	4·8	5·1	5·7	6·1	6·4	6·3	6·2	6·2	6·2	6·2	6·2	6·3	5·8
August	6·6	6·5	6·5	6·5	6·5	6·6	6·8	6·7	6·0	5·0	4·4	4·5	4·8	5·2	5·7	6·3	6·5	6·7	6·6	6·5	6·6	6·6	6·6	6·6	6·6	6·1
September	6·6	6·6	6·6	6·6	6·6	6·6	6·9	7·0	6·2	5·1	4·3	4·0	4·4	5·0	5·8	6·3	6·6	6·5	6·3	6·5	6·6	6·6	6·6	6·6	6·6	6·1
Means	6·5	6·4	6·4	6·4	6·4	6·4	6·6	6·5	5·8	5·0	4·3	4·2	4·4	4·8	5·4	6·0	6·3	6·5	6·4	3·3	6·4	6·4	6·5	6·5	6·5	5·9

Diurnal Inequality of the Dip at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·4	+0·4	+0·4	+0·4	+0·3	+0·3	+0·2	0	−0·3	−0·6	−1·0	−1·1	−1·1	−0·5	−0·2	0	+0·1	+0·2	+0·3	+0·3	+0·4	+0·5	+0·4	+0·4	+0·4
February	+0·5	+0·5	+0·5	+0·4	+0·4	+0·4	+0·4	+0·2	−0·2	−0·7	−1·3	−1·5	−1·3	−0·8	−0·2	+0·1	+0·2	+0·2	+0·2	+0·4	+0·5	+0·6	+0·5	+0·6	+0·5
March	+0·6	+0·5	+0·6	+0·6	+0·5	+0·5	+0·6	+0·6	+0·1	−0·7	−1·4	−1·9	−1·9	−1·4	−0·7	0	+0·3	+0·4	+0·4	+0·4	+0·5	+0·5	+0·6	+0·6	+0·7
October	+0·5	+0·5	+0·5	+0·5	+0·4	+0·5	+0·7	+0·7	+0·3	−0·7	−1·6	−2·0	−1·9	−1·0	−0·2	+0·2	+0·3	+0·3	+0·3	+0·4	+0·4	+0·5	+0·5	+0·5	+0·4
November	+0·5	+0·4	+0·4	+0·4	+0·4	+0·3	+0·3	+0·2	−0·1	−0·7	−1·1	−1·3	−1·2	−0·8	−0·5	−0·1	+0·2	+0·2	+0·3	+0·4	+0·5	+0·5	+0·5	+0·5	+0·5
December	+0·5	+0·5	+0·5	+0·5	+0·5	+0·3	+0·3	0	0	−0·2	−0·7	−1·0	−1·4	−1·1	−0·7	−0·2	+0·1	+0·3	+0·3	+0·4	+0·4	+0·4	+0·4	+0·5	+0·5
Means	+0·5	+0·4	+0·5	+0·4	+0·4	+0·4	+0·4	+0·3	−0·1	−0·6	−1·2	−1·5	−1·5	−1·0	−0·4	0	+0·2	+0·2	+0·3	+0·4	+0·4	+0·5	+0·5	+0·5	+0·5
Summer.																									
April	+0·7	+0·7	+0·7	+0·6	+0·6	+0·5	+0·7	+0·6	−0·1	−1·1	−1·9	−2·1	−1·9	−1·4	−0·7	−0·1	+0·3	+0·5	+0·4	+0·5	+0·6	+0·6	+0·6	+0·7	+0·7
May	+0·6	+0·5	+0·5	+0·4	+0·4	+0·5	+0·7	+0·5	−0·1	−0·9	−1·5	−1·7	−1·6	−1·2	−0·5	0	+0·3	+0·5	+0·4	+0·4	+0·5	+0·5	+0·6	+0·6	+0·6
June	+0·5	+0·4	+0·4	+0·4	+0·4	+0·4	+0·6	+0·4	−0·2	−0·9	−1·3	−1·6	−1·5	−1·1	−0·5	0	+0·4	+0·6	+0·5	+0·3	+0·4	+0·5	+0·5	+0·5	+0·5
July	+0·5	+0·4	+0·4	+0·4	+0·4	+0·5	+0·6	+0·3	−0·2	−0·9	−1·4	−1·5	−1·4	−1·0	−0·7	−0·1	+0·3	+0·6	+0·5	+0·4	+0·4	+0·4	+0·4	+0·4	+0·5
August	+0·5	+0·4	+0·4	+0·4	+0·4	+0·5	+0·7	+0·6	−0·1	−1·1	−1·7	−1·6	−1·3	−0·9	−0·4	+0·2	+0·4	+0·6	+0·5	+0·4	+0·5	+0·5	+0·5	+0·5	+0·5
September	+0·5	+0·5	+0·5	+0·5	+0·5	+0·5	+0·8	+0·9	+0·1	−1·0	−1·8	−2·1	−1·7	−1·1	−0·3	+0·2	+0·5	+0·4	+0·2	+0·4	+0·5	+0·5	+0·5	+0·5	+0·5
Means	+0·6	+0·5	+0·5	+0·5	+0·5	+0·5	+0·7	+0·6	−0·1	−0·9	−1·6	−1·7	−1·5	−1·1	−0·5	+0·1	+0·4	+0·6	+0·5	+0·4	+0·5	+0·5	+0·6	+0·6	+0·6

NOTE.—When the sign is + the Dip is more, and when − it is less than the m ean.

F.—*Tables of results at Kodaikānal.*

Hourly Means of the Declination as determined at Kodaikānal from all available days in 1914.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
													Winter.													
						W 1° +																				
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	14·3	14·3	14·4	14·5	14·6	14·7	14·9	15·2	15·3	15·0	14·9	15·0	14·7	14·3	13·9	13·6	13·6	14·1	14·2	14·2	14·2	14·3	14·3	14·3	14·3	14·5
February .	14·9	14·8	14·8	14·8	14·9	15·0	15·0	15·1	15·4	15·6	15·6	15·7	15·5	14·9	14·3	13·9	13·8	14·2	14·6	14·6	14·8	14·8	14·9	14·9	14·9	14·9
March .	15·2	15·2	15·2	15·2	15·2	15·3	15·3	15·2	14·9	14·8	14·8	15·3	15·8	16·1	15·8	15·4	14·9	14·9	15·1	15·2	15·3	15·3	15·2	15·2	15·2	15·2
October .	19·4	19·4	19·4	19·4	19·5	19·5	19·4	18·9	18·5	18·6	19·2	20·1	20·4	19·8	19·3	18·7	18·5	18·8	19·2	19·3	19·4	19·4	19·4	19·4	19·4	19·3
November .	19·7	19·7	19·8	20·0	20·2	20·3	20·3	20·5	20·2	19·9	20·0	20·2	19·9	19·6	19·3	19·2	19·2	19·4	19·4	19·5	19·6	19·6	19·7	19·7	19·7	19·8
December .	20·1	20·2	20·3	20·3	20·5	20·6	20·8	21·4	21·1	20·5	20·0	19·8	19·7	19·8	19·8	20·0	20·0	20·0	20·1	20·1	20·1	20·2	20·2	20·2	20·1	20·2
Means .	17·3	17·3	17·3	17·4	17·5	17·6	17·6	17·7	17·6	17·4	17·4	17·7	17·7	17·4	17·1	16·8	16·7	16·9	17·1	17·2	17·2	17·3	17·3	17·3	17·3	17·3
													Summer.													
April .	15·5	15·5	15·5	15·5	15·5	15·5	15·4	14·9	14·7	14·9	15·4	16·0	16·7	16·9	16·5	16·0	15·6	15·5	15·7	16·0	16·1	16·0	15·8	15·8	15·5	15·7
May .	16·2	16·2	16·1	16·1	16·1	16·0	15·3	14·8	14·6	15·3	16·2	17·3	17·8	17·8	17·4	16·8	16·4	16·1	16·2	16·5	16·5	16·5	16·4	16·3	16·2	16·3
June .	16·4	16·3	16·3	16·3	16·3	16·2	15·7	15·1	15·1	15·6	16·7	17·5	18·2	18·2	17·7	17·2	16·7	16·7	16·9	17·1	17·1	17·1	16·9	16·7	16·5	16·7
July .	17·1	17·0	16·8	16·8	16·7	16·5	16·0	15·2	15·2	16·0	16·9	17·9	18·6	18·8	18·4	17·7	17·2	17·0	17·1	17·3	17·3	17·3	17·3	17·2	17·1	17·1
August .	17·5	17·5	17·4	17·3	17·3	17·2	16·3	15·6	15·6	16·5	17·7	18·8	19·6	19·4	18·9	18·1	17·5	17·0	17·2	17·7	17·7	17·8	17·8	17·6	17·5	17·5
September .	18·4	18·4	18·3	18·3	18·2	18·0	17·3	16·4	16·2	17·1	18·5	19·9	20·4	20·3	19·5	18·4	17·8	17·7	18·2	18·4	18·5	18·5	18·5	18·5	18·4	18·3
Means .	16·9	16·8	16·7	16·7	16·7	16·6	16·0	15·3	15·2	15·9	16·9	17·9	18·6	18·6	18·1	17·4	16·9	16·7	16·9	17·2	17·2	17·2	17·1	17·0	16·9	16·9

Diurnal Inequality of the Declination at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·2	+0·2	+0·1	0	−0·1	−0·2	−0·4	−0·7	−0·8	−0·5	−0·4	−0·5	−0·2	+0·2	+0·6	+0·9	+0·9	+0·4	+0·3	+0·3	+0·3	+0·2	+0·2	+0·2	+0·2
February	0	+0·1	+0·1	+0·1	0	−0·1	−0·1	−0·2	−0·5	−0·7	−0·7	−0·8	−0·6	0	+0·6	+1·0	+1·1	+0·7	+0·3	+0·3	+0·1	+0·1	0	0	0
March	0	0	0	0	0	−0·1	−0·1	0	+0·3	+0·4	+0·4	−0·1	−0·6	−0·9	−0·6	−0·2	+0·3	+0·3	+0·1	0	−0·1	−0·1	0	0	0
October	−0·1	−0·1	−0·1	−0·1	−0·2	−0·2	−0·1	+0·4	+0·8	+0·7	+0·1	−0·8	−1·1	−0·5	0	+0·6	+0·8	+0·5	+0·1	0	−0·1	−0·1	−0·1	−0·1	−0·1
November	+0·1	+0·1	0	−0·2	−0·4	−0·5	−0·5	−0·7	−0·4	−0·1	−0·2	−0·4	−0·1	+0·2	+0·5	+0·6	+0·6	+0·4	+0·4	+0·3	+0·2	+0·2	+0·1	+0·1	+0·1
December	+0·1	0	−0·1	−0·1	−0·3	−0·4	−0·6	−1·2	−0·9	−0·3	+0·2	+0·4	+0·5	+0·4	+0·4	+0·2	+0·2	+0·2	+0·1	+0·1	+0·1	0	0	0	+0·1
Means	0	0	0	−0·1	−0·2	−0·3	−0·3	−0·4	−0·3	−0·1	−0·1	−0·4	−0·4	−0·1	+0·2	+0·5	+0·6	+0·4	+0·2	+0·1	+0·1	0	0	0	0
Summer.																									
April	+0·2	+0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·8	+1·0	+0·8	+0·3	−0·3	−1·0	−1·2	−0·8	−0·3	+0·1	+0·2	+0	−0·3	−0·4	−0·3	−0·1	−0·1	+0·2
May	+0·1	+0·1	+0·2	+0·2	+0·2	+0·3	+1·0	+1·5	+1·7	+1·0	+0·1	−1·0	−1·5	−1·5	−1·1	−0·5	−0·1	+0·2	+0·1	−0·2	−0·2	−0·2	−0·1	0	+0·1
June	+0·3	+0·4	+0·4	+0·4	+0·4	+0·5	+1·0	+1·6	+1·6	+1·1	0	−0·8	−1·5	−1·5	−1·0	−0·5	0	0	−0·2	−0·4	−0·4	−0·4	−0·2	0	+0·2
July	0	+0·1	+0·3	+0·3	+0·4	+0·6	+1·1	+1·9	+1·9	+1·1	−0·2	−0·8	−1·5	−1·7	−1·3	−0·6	−0·1	+0·1	0	−0·2	−0·2	−0·2	−0·2	−0·1	0
August	0	0	+0·1	+0·2	+0·2	+0·3	+1·2	+1·9	+1·9	+1·0	−0·2	−1·3	−2·1	−1·9	−1·4	−0·6	0	+0·5	+0·3	−0·2	−0·2	−0·3	−0·3	−0·1	0
September	−0·1	−0·1	0	0	+0·1	+0·3	+1·0	+1·9	+2·1	+1·2	−0·2	−1·6	−2·1	−2·0	−1·2	−0·1	+0·5	+0·6	+0·1	−0·1	−0·2	−0·2	−0·2	−0·2	−0·1
Means	0	+0·1	+0·2	+0·2	+0·2	+0·3	+0·9	+1·6	+1·7	+1·0	0	−1·0	−1·7	−1·7	−1·2	−0·5	0	+0·2	0	−0·3	−0·3	−0·3	−0·2	−0·1	0

NOTE.—When the sign is + the magnet points to the East, and when — to the West of the mean position.

Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Kodaikānal from all available days in 1914.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
	·37000 C. G. S. +												Winter.													
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	558	560	560	561	560	562	563	570	581	596	**603**	603	594	582	568	562	561	563	562	560	559	558	**557**	557	558	569
February .	561	561	563	564	565	565	565	569	583	602	617	**623**	615	598	579	569	566	568	567	563	560	560	**558**	560	561	575
March .	554	555	555	556	557	557	556	559	574	597	618	**629**	623	606	588	572	563	559	558	556	555	555	**552**	553	555	571
October .	**556**	557	558	560	560	560	558	564	584	611	628	**631**	617	593	572	561	558	560	559	557	557	556	556	557	557	572
November .	556	556	**557**	559	561	560	563	570	585	600	**613**	613	603	590	577	567	563	561	557	554	553	554	554	554	556	570
December .	**556**	557	558	559	559	560	562	569	577	588	600	607	**609**	602	590	579	568	562	562	561	561	558	557	558	556	572
Means .	557	558	559	560	560	561	561	567	581	599	613	**618**	610	595	579	568	563	562	561	559	558	557	**556**	557	557	572
													Summer.													
April .	550	551	552	554	555	554	555	559	582	608	628	**633**	624	604	580	563	556	556	557	553	552	551	550	**549**	551	570
May .	559	560	562	562	562	531	563	567	583	603	620	**624**	618	604	586	569	560	557	559	558	558	558	557	**557**	559	574
June .	559	561	560	561	560	559	561	564	575	591	602	**609**	605	592	578	563	555	**554**	557	557	556	555	557	558	559	569
July .	559	560	561	561	560	560	564	569	579	595	600	**606**	599	591	578	565	554	**552**	555	556	555	556	556	558	560	569
August .	558	558	559	560	560	561	563	566	579	600	609	**611**	600	581	564	554	**549**	549	555	554	555	555	556	556	558	567
September .	561	562	563	564	564	565	564	568	591	620	**634**	631	614	593	576	564	560	561	563	559	**557**	557	558	559	562	575
Means .	558	559	560	560	560	560	562	566	582	603	616	**619**	510	594	577	563	556	**555**	558	556	556	555	556	556	558	571

Diurnal Inequality of the Horizontal Force at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
													Winter.												
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January . .	−11	−9	−9	−8	−9	−7	−6	+1	+12	+27	+34	+34	+25	+13	−1	−7	−8	−6	−7	−9	−10	−11	−12	−12	−11
February . .	−14	−14	−12	−11	−10	−10	−10	−6	+8	+27	+42	+48	+40	+23	+4	−6	−9	−7	−8	−12	−15	−15	−17	−15	−14
March . .	−17	−16	−16	−15	−14	−14	−15	−12	+3	+26	+47	+58	+52	+35	+17	+1	−8	−12	−13	−15	−16	−16	−19	−18	−16
October . .	−16	−15	−14	−12	−12	−12	−14	−8	+12	+39	+56	+59	+45	+21	0	−11	−14	−12	−13	−15	−15	−16	−16	−15	−15
November . .	−14	−14	−13	−11	−9	−10	−7	0	+15	+30	+43	+43	+33	+20	+7	−3	−7	−9	−13	−16	−17	−16	−16	−16	−14
December . .	−16	−15	−14	−13	−13	−12	−10	−3	+5	+16	+28	+35	+37	+30	+18	+7	−4	−10	−10	−11	−11	−14	−15	−14	−16
Means . .	−15	−14	−13	−12	−12	−11	−11	−5	+9	+27	+41	+46	+38	+23	+7	−4	−9	−10	−11	−13	−14	−15	−16	−15	−15
													Summer.												
April . . .	−20	−19	−18	−16	−15	−16	−15	−11	+12	+38	+58	+63	+54	+34	+10	−7	−14	−14	−13	−17	−18	−19	−20	−21	−19
May . . .	−15	−14	−12	−12	−12	−13	−11	−7	+9	+29	+46	+50	+44	+30	+12	−5	−14	−17	−15	−16	−16	−16	−17	−17	−15
June . . .	−10	−8	−9	−8	−9	−10	−8	−5	+6	+22	+33	+40	+36	+23	+9	−6	−14	−15	−12	−12	−13	−14	−12	−11	−10
July . . .	−10	−9	−8	−8	−9	−9	−5	0	+10	+26	+31	+37	+30	+22	+9	−4	−15	−17	−14	−13	−14	−13	−13	−11	−9
August . .	−9	−9	−8	−7	−7	−6	−4	−1	+12	+33	+42	+44	+33	+14	−3	−13	−18	−18	−12	−13	−12	−12	−11	−11	−9
September . .	−14	−13	−12	−11	−11	−10	−11	−7	+16	+45	+59	+56	+39	+18	+1	−11	−15	−14	−12	−16	−18	−18	−17	−16	−13
Means . .	−13	−12	−11	−11	−11	−11	−9	−5	+11	+32	+45	+48	+39	+23	+6	−8	−15	−16	−13	−15	−15	−16	−15	−15	−13

NOTE.—When the sign is + the H. F. is greater, and when — it is less than the mean.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Kodaikānal from all available days in 1914.

Hours	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
·02000 C. G. S. +													Winter.													
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	719	720	719	719	719	719	719	718	716	713	709	710	712	714	716	720	718	715	717	717	718	718	718	719	719	717
February .	725	725	726	725	725	724	725	723	719	713	709	707	711	716	719	723	722	719	720	721	721	723	723	724	725	720
March .	733	733	733	738	733	733	734	735	733	728	721	714	711	711	714	717	721	726	728	729	731	731	731	733	734	727
October .	771	772	772	772	772	773	775	773	767	760	751	746	752	758	762	764	765	765	767	768	769	771	771	773	772	766
November .	782	782	782	782	783	782	782	782	781	777	772	770	770	769	770	773	775	776	777	778	780	781	782	782	783	778
December .	778	779	780	780	780	779	779	778	779	779	777	773	768	762	760	764	770	773	775	777	777	778	778	779	778	775
Means .	751	752	752	752	752	752	752	752	749	745	740	737	737	738	740	744	745	746	747	748	749	750	751	752	752	747
													Summer.													
April .	740	741	740	741	740	741	743	744	738	730	723	716	714	718	724	732	737	736	735	736	737	738	740	740	741	734
May .	748	748	748	747	747	748	752	751	746	739	731	727	726	728	733	739	745	746	745	744	745	746	747	747	748	743
June .	758	758	758	758	758	758	761	762	762	756	753	748	746	748	751	755	756	756	755	755	755	757	758	758	758	756
July .	761	761	761	760	760	762	764	764	760	754	751	750	751	753	758	760	762	763	759	758	758	759	760	761	761	759
August .	767	767	767	767	767	769	772	771	764	756	749	746	751	759	768	773	774	770	763	763	765	765	766	766	767	764
September .	773	772	772	773	773	774	777	775	766	752	742	739	743	751	760	766	769	767	765	766	768	769	770	771	773	765
Means .	758	758	758	758	758	759	762	761	756	748	742	738	739	743	749	754	757	756	754	754	755	756	757	757	758	754

Diurnal Inequality of the Vertical Force at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January . .	+2	+3	+2	+2	+2	+2	+2	+1	−1	−4	−8	−7	−5	−3	−1	+3	+1	−2	0	0	+1	+1	+1	+2	+2
February . .	+5	+5	+6	+5	+5	+4	+5	+3	−1	−7	−11	−13	−9	−4	−1	+3	+2	−1	0	+1	+1	+3	+3	+4	+5
March . . .	+6	+6	+6	+6	+6	+6	+7	+8	+6	+1	−6	−13	−16	−16	−13	−10	−6	−1	+1	+2	+4	+4	+4	+6	+7
October . .	+5	+6	+6	+6	+6	+7	+9	+7	+1	−6	−15	−20	−14	−8	−4	−2	−1	−1	+1	+2	+3	+5	+5	+7	+6
November . .	+4	+4	+4	+4	+5	+4	+4	+4	+3	−1	−6	−8	−8	−9	−8	−5	−3	−2	−1	0	+2	+3	+4	+4	+5
December . .	+3	+4	+5	+5	+5	+4	+4	+3	+4	+4	+2	−2	−7	−13	−15	−11	−5	−2	0	+2	+2	+3	+3	+4	+3
Means . .	+4	+5	+5	+5	+5	+5	+5	+5	+2	−2	−7	−10	−10	−9	−7	−3	−2	−1	0	+1	+2	+3	+4	+5	+5
Summer.																									
April . . .	+6	+7	+6	+7	+6	+7	+9	+10	+4	−4	−11	−18	−20	−16	−10	−2	+3	+2	+1	+2	+3	+4	+6	+6	+7
May . . .	+5	+5	+5	+4	+4	+5	+9	+8	+3	−4	−12	−16	−17	−15	−10	−4	+2	+3	+2	+1	+2	+3	+4	+4	+5
June . . .	+2	+2	+2	+2	+2	+2	+5	+6	+6	0	−3	−8	−10	−8	−5	−1	0	0	−1	−1	−1	+1	+2	+2	+2
July . . .	+2	+2	+2	+1	+1	+3	+5	+5	+1	−5	−8	−9	−8	−6	−1	+1	+3	+4	0	−1	−1	0	+1	+2	+2
August . .	+3	+3	+3	+3	+3	+5	+8	+7	0	−8	−15	−18	−13	−5	+4	+9	+10	+6	−1	−1	+1	+1	+2	+2	+3
September . .	+8	+7	+7	+8	+8	+9	+12	+10	+1	−13	−23	−26	−22	−14	−5	+1	+4	+2	0	+1	+3	+4	+5	+6	+8
Means . .	+4	+4	+4	+4	+4	+5	+8	+7	+2	−6	−12	−16	−15	−11	−5	0	+3	+2	0	0	+1	+2	+3	+3	+4

Note.—When the sign is + the H. F. is greater, and when − it is less than the mean.

Hourly Means of the Dip as determined at Kodaikānal from all available days in 1914.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
													Winter.													
						N 4° +																				
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	8·5	8·5	8·4	8·4	8·4	8·4	8·4	8·3	8·0	7·7	7·2	7·3	7·6	7·8	8·1	8·5	8·3	8·1	8·2	8·3	8·4	8·4	8·4	8·5	8·5	8·2
February	9·0	9·0	9·1	9·0	9·0	8·9	9·0	8·7	8·3	7·6	7·2	6·9	7·3	7·9	8·3	8·7	8·7	8·4	8·5	8·6	8·6	8·8	8·8	8·9	9·0	8·5
March	9·7	9·7	9·7	9·7	9·7	9·7	9·8	9·9	9·6	9·0	8·2	7·5	7·3	7·4	7·8	8·2	8·6	9·1	9·3	9·4	9·6	9·6	9·6	9·8	9·8	9·1
October	13·2	13·3	13·3	13·3	13·3	13·4	13·5	13·3	12·6	11·8	10·9	10·4	11·1	11·8	12·3	12·5	12·6	12·6	12·8	12·9	13·0	13·2	13·2	13·4	13·3	12·7
November	14·2	14·2	14·2	14·2	14·3	14·2	14·2	14·1	13·9	13·4	12·9	12·7	12·8	12·8	13·0	13·3	13·5	13·6	13·7	13·8	14·0	14·1	14·2	14·2	14·3	13·7
December	13·8	13·9	14·0	14·0	14·0	13·9	13·9	13·7	13·8	13·7	13·4	13·0	12·6	12·1	12·0	12·4	13·0	13·3	13·5	13·7	13·7	13·8	13·8	13·9	13·8	13·5
Means	11·4	11·4	11·5	11·4	11·5	11·4	11·5	11·3	11·0	10·5	10·0	9·6	9·8	10·0	10·3	10·6	10·8	10·9	11·0	11·1	11·2	11·3	11·3	11·5	11·5	10·9
													Summer.													
April	10·4	10·5	10·4	10·5	10·4	10·5	10·7	10·7	10·0	9·1	8·4	7·7	7·6	8·1	8·8	9·6	10·1	10·0	9·9	10·0	10·1	10·2	10·4	10·4	10·5	9·8
May	11·1	11·1	11·1	11·0	11·0	11·1	11·4	11·3	10·7	10·0	9·1	8·7	8·7	9·0	9·5	10·2	10·8	10·9	10·8	10·7	10·8	10·9	11·0	11·0	11·1	10·5
June	12·0	12·0	12·0	12·0	12·0	12·0	12·3	12·3	12·2	11·6	11·3	10·8	10·6	10·9	11·2	11·7	11·8	11·8	11·7	11·7	11·7	11·9	12·0	12·0	12·0	11·7
July	12·3	12·3	12·3	12·2	12·2	12·3	12·5	12·5	12·0	11·4	11·1	10·9	11·1	11·3	11·9	12·1	12·4	12·5	12·1	12·0	12·0	12·1	12·2	12·3	12·3	12·0
August	12·8	12·8	12·8	12·8	12·8	13·0	13·2	13·1	12·4	11·5	10·8	10·6	11·1	11·9	12·9	13·4	13·5	13·2	12·5	12·5	12·7	12·7	12·7	12·7	12·8	12·5
September	13·3	13·2	13·2	13·3	13·3	13·4	13·7	13·5	12·5	11·0	10·0	9·8	10·3	11·1	12·1	12·7	13·0	12·8	12·6	12·7	12·9	13·0	13·1	13·2	13·3	12·5
Means	12·0	12·0	12·0	12·0	12·0	12·1	12·3	12·2	11·6	10·8	10·1	9·8	9·9	10·4	11·1	11·6	11·9	11·9	11·6	11·6	11·7	11·8	11·9	11·9	12·0	11·5

Diurnal Inequality of the Dip at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1914 Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·3	+0·3	+0·2	+0·2	+0·2	+0·2	+0·2	+0·1	−0·2	−0·5	−1·0	−0·9	−0·6	−0·4	−0·1	+0·3	+0·1	−0·1	0	+0·1	+0·2	+0·2	+0·2	+0·3	+0·3
February	+0·5	+0·5	+0·6	+0·5	+0·5	+0·4	+0·5	+0·2	−0·2	−0·9	−1·3	−1·6	−1·2	−0·6	−0·2	+0·2	+0·2	−0·1	0	+0·1	+0·1	+0·3	+0·3	+0·4	+0·5
March	+0·6	+0·6	+0·6	+0·6	+0·6	+0·6	+0·7	+0·8	+0·5	−0·1	−0·9	−1·6	−1·8	−1·7	−1·3	−0·9	−0·5	0	+0·2	+0·3	+0·5	+0·5	+0·5	+0·7	+0·7
October	+0·5	+0·6	+0·6	+0·6	+0·6	+0·7	+0·8	+0·6	−0·1	−0·9	−1·8	−2·3	−1·6	−0·9	−0·4	−0·2	−0·1	−0·1	+0·1	+0·2	+0·3	+0·5	+0·5	+0·7	+0·6
November	+0·5	+0·5	+0·5	+0·5	+0·6	+0·5	+0·5	+0·4	+0·2	−0·3	−0·8	−1·0	−0·9	−0·9	−0·7	−0·4	−0·2	−0·1	0	+0·1	+0·3	+0·4	+0·5	+0·5	+0·6
December	+0·3	+0·4	+0·5	+0·5	+0·5	+0·4	+0·4	+0·2	+0·3	+0·2	−0·1	−0·5	−0·9	−1·4	−1·5	−1·1	−0·5	−0·2	0	+0·2	+0·2	+0·3	+0·3	+0·4	+0·3
Means	+0·5	+0·5	+0·6	+0·5	+0·6	+0·5	+0·6	+0·4	+0·1	−0·4	−0·9	−1·3	−1·1	−0·9	−0·6	−0·3	−0·1	0	+0·1	+0·2	+0·3	+0·4	+0·4	+0·6	+0·6
Summer.																									
April	+0·6	+0·7	+0·6	+0·7	+0·6	+0·7	+0·9	+0·9	+0·2	−0·7	−1·4	−2·1	−2·2	−1·7	−1·0	−0·2	+0·3	+0·2	+0·1	+0·2	+0·3	+0·4	+0·6	+0·6	+0·7
May	+0·6	+0·6	+0·6	+0·5	+0·5	+0·6	+0·9	+0·8	+0·2	−0·5	−1·4	−1·8	−1·8	−1·5	−1·0	−0·8	+0·3	+0·4	+0·3	+0·2	+0·3	+0·4	+0·5	+0·5	+0·6
June	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·6	+0·6	+0·5	−0·1	−0·4	−0·9	−1·1	−0·8	−0·5	0	+0·1	+0·1	0	0	0	+0·2	+0·3	+0·3	+0·3
July	+0·3	+0·3	+0·3	+0·2	+0·2	+0·3	+0·5	+0·5	0	−0·6	−0·9	−1·1	−0·9	−0·7	−0·1	+0·1	+0·4	+0·5	+0·1	0	0	+0·1	+0·2	+0·3	+0·3
August	+0·3	+0·3	+0·3	+0·3	+0·3	+0·5	+0·7	+0·6	−0·1	−1·0	−1·7	−1·9	−1·4	−0·6	+0·4	+0·9	+1·0	+0·7	0	0	+0·2	+0·2	+0·2	+0·2	+0·3
September	+0·8	+0·7	+0·7	+0·8	+0·8	+0·9	+1·2	+1·0	0	−1·5	−2·5	−2·7	−2·2	−1·4	−0·4	+0·2	+0·5	+0·3	+0·1	+0·2	+0·4	+0·5	+0·6	+0·7	+0·8
Means	+0·5	+0·5	+0·5	+0·5	+0·5	+0·6	+0·8	+0·7	+0·1	−0·7	−1·4	−1·7	−1·6	−1·1	−0·4	+0·1	+0·4	+0·4	+0·1	+0·1	+0·2	+0·3	+0·4	+0·4	+0·5

NOTE.—When the sign is + the Dip is more, and when − it is less than the mean.

G.—Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1914-15.

REPEAT STATIONS.

Serial No.	Name of Station.	Latitude.			Longitude.			Dip.		Declination.		Horizontal Force.	Remarks.
		°	'	"	°	'	"	°	'	°	'	C. G. S.	
I. Site 3	Udaipur	24	34	42	73	42	46	34	42	E 1	9	·3523	H is derived from mean " m " throughout.
Ditto	Do.		...			...		34	43	„ 1	10	·3522	
II. Site 2	Karāchi	24	49	24	67	2	28	35	10	„ 1	38	·3448	
III. Site 2	Quetta	30	12	21	66	59	55	44	0	„ 2	59	·3210	
Ditto	Do.		...			...		44	1	„ 2	59	·3211	
IV. Site 1	Bahāwalpur	29	24	23	71	40	35	43	3	„ 2	41	·3299	
Ditto	Do.		...			...		43	4	„ 2	43	·3296	
V. Site 3	Rāwalpindi	33	35	25	73	3	6	49	4	„ 3	32	·3094	
Ditto	Do		...			...		49	4	„ 3	31	·3096	
VI. Site 3	Bharatpur	27	13	53	77	29	24	39	31	„ 1	39	·3449	
Ditto	Do.		...			...		39	32	„ 1	39	·3450	
VII. Site 1	Bangalore	12	58	43	77	35	26	10	40	W 1	14	·3848	
Ditto	Do.		...			...		10	40	„ 1	11	·3845	
VIII. Site 1	Dhārwār	15	26	36	75	0	10	16	16	„ 0	41	·3778	
Ditto	Do.		...			...		16	16	„ 0	38	·3777	
IX. Site 2	Porbandar	21	37	43	69	36	39	29	37	E 1	2	·3607	
Ditto	Do.		...			...		29	35	„ 0	59	·3607	
X. Site 3	Fyzābād	26	48	5	82	8	5	38	42	„ 1	19	·3527	
Ditto	Do.		...			...		38	41	„ 1	21	·3526	
XI. Site 1	Sambalpur	21	27	52	83	58	35	28	27	„ 0	13	·3745	
Ditto	Do.		...			...		28	28	„ 0	13	·3747	
XII. Site 1	Waltair	17	42	23	83	17	44	21	18	W 0	17	·3832	
Ditto	Do.		...			...		21	17	„ 0	16	·3831	
XIII. Site 2	Darjeeling	26	59	42	88	16	56	38	52	E 1	1	·3572	
Ditto	Do.		...			...		38	54	„ 1	0	·3569	
XIV. Site 1	Gayā	24	47	7	84	59	47	35	3	„ 0	40	·3670	
Ditto	Do.		...			...		35	2	„ 0	41	·3671	
XV. Site 3	Secunderābād	17	27	44	78	29	37	21	8	W 0	15	·3806	
Ditto	Do.		...			...		21	8	„ 0	14	·3804	
XVI. Site 1	Bhusāwal	21	3	40	75	47	0	27	58	E 0	19	·3684	
Ditto	Do.		...			...		27	57	„ 0	21	·3683	
XVII. Site 1	Jubbulpore	23	9	26	79	57	9	31	48	„ 0	35	·3655	
Ditto	Do.		...			...		31	46	„ 0	36	·3657	
XVIII. Site 1	Tavoy	14	5	3	98	12	14	12	9	„ 0	0	·3983	
Ditto	Do.		...			...		12	9	W 0	0	·3985	
XIX. Site 2	Lashio	22	56	12	97	44	48	31	22	E 0	10	·3788	
Ditto	Do.		...			...		31	18	„ 0	12	·3790	
XX. Site 1	Akyab	20	8	6	92	53	37	25	46	„ 0	7	·3853	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1914-15—contd.

REPEAT STATIONS—*contd.*

Serial No.	Name of Station.	Latitude.			Longitude.			Dip.		Declination.		Horizontal Force.	REMARKS.
		°	′	″	°	′	″	°	′	°	′	C. G. S.	
XX. Site 1	Akyab		...			...		25	47	E 0	7	·3858	H is derived from mean "m" throughout.
XXI. Site 1	Silchar or Cāchār	24	49	14	92	47	27	35	0	„ 0	30	·3709	
Ditto	Ditto		...			...		35	2	„ 0	32	·3707	
XXII. Site 3	Dibrugarh	27	29	12	94	54	35	39	49	„ 0	39	·3590	
Ditto	Do.		...			...		39	49	„ 0	38	·3593	
46	Ruk Junction	27	48	23	68	38	20	40	18	„ 2	0	·3337	
46	Ditto		...			...		40	17	„ 1	59	·3340	
71	Lahore	31	35	50	74	18	50	46	45	„ 2	46	·3191	
71	Do.		...			...		46	47	„ 2	46	·3191	
88	Peshāwar	34	0	40	71	33	40	49	37	„ 3	43	·3064	
88	Do.		...			...		49	35	„ 3	42	·3065	
92	Kundiān	32	27	30	71	28	20	48	19	„ 3	20	·3085	
92(*a*)	Do.	32	27	30	71	28	20	48	21	„ 3	20	·3083	
105	Sachīn	21	4	40	72	52	40	28	20	„ 0	10	·3654	
105	Do.		...			...		28	18	„ 0	9	·3657	
124	Bīkaner	28	0	40	73	18	50	40	53	„ 1	50	·3378	
124(*a*)	Do.	28	0	40	73	18	50	40	50	„ 1	51	·3377	
130	Ajmer	26	27	30	74	38	30	38	4	„ 1	43	·3459	
130	Do.		...			...		38	4	„ 1	43	·3459	
134	Mīrpur Khās	25	31	40	69	0	40	36	28	„ 1	45	·3440	
134(*a*)	Do.	25	31	19	69	1	40	36	28	„ 1	45	·3439	
139	Viramgām	23	8	10	72	3	30	32	8	„ 0	55	·3565	
139	Do.		...			...		32	8	„ 0	54	·3567	
172	Dhond	18	28	0	74	35	10	23	11	„ 0	6	·3708	
172	Do.		...			...		23	3	„ 0	9	·3713	
175	Hotgi	17	33	40	76	0	20	21	6	W 0	8	·3754	
175	Do.		...			...		20	59	„ 0	8	·3761	
181	Guntakal	15	10	48	77	22	57	15	56	„ 0	47	·3808	
181	Do.		...			...		15	57	„ 0	45	·3804	
186	Arkonam	13	4	30	79	40	20	10	48	„ 1	18	·3870	
186	Do.		...			...		10	50	„ 1	18	·3864	
187	Perambūr	13	6	40	80	15	0	10	56	„ 1	11	·3854	
187	Do.		...			...		10	57	„ 1	11	·3850	
199	Cannanore	11	52	30	75	22	0	9	5	„ 1	39	·3816	
199	Do.		...			...		9	6	„ 1	41	·3816	
207	Birūr	13	35	50	75	58	10	12	18	„ 1	2	·3807	
207	Do.		...			...		12	19	„ 0	58	·3803	
216	Mirāj	16	49	10	74	38	10	20	7	„ 0	27	·3776	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1914-15—contd.

REPEAT STATIONS—*contd.*

Serial No.	Name of Station.	Latitude.			Longitude.			Dip.		Declination.			Horizontal Force.	REMARKS.
		°	'	"	°	'	"	°	'		°	'	C. G. S.	
216	Mirāj		...			...		20	11	E	0	24	·3773	H is derived from mean "m" throughout.
223	Manmād	20	14	40	74	26	20	26	44	„	0	36	·3666	
223(*a*)	Do.	20	14	40	74	26	20	26	55	„	0	33	·3715	
232(*a*)	Delhi	28	40	20	77	14	20	41	52	E	1	46	·3394	
232(*a*)	Do.		...			...		41	51	„	1	47	·3395	
283	Sirsa	29	32	10	75	2	40	43	10	„	2	22	·3328	
283	Do.		...			...		43	11	„	2	22	·3327	
328(*a*)	Tinnevelly	8	44	0	77	42	30	1	20	W	2	2	·3806	
328(*a*)	Do.		...			...		1	21	„	2	1	·3804	
332	Mandapam	9	16	50	79	8	30	1	58	„	1	50	·3838	
332	Do.		...			...		1	58	„	1	50	·3839	
337	Tanjore	10	46	40	79	8	20	5	9	„	1	46	·3837	
337(*a*)	Do.	10	46	40	79	8	20	5	10	„	1	44	·3835	
375	Parbhani	19	15	20	76	46	50	25	15	E	0	1	·3729	
375(*a*)	Do.	19	15	20	76	46	50	25	6	W	0	3	·3696	
384	Bezwāda	16	31	0	80	36	50	18	20	„	0	52	·3828	
384(*a*)	Do.	16	31	0	80	36	50	18	20	„	0	52	·3825	
483	Mānikpur	25	3	10	81	5	20	35	36	E	0	58	·3589	
483	Do.		...			...		35	35	„	0	59	·3590	
489	Monghyr	25	23	10	86	27	50	36	0	„	0	47	·3633	
489	Do.		...			...		36	0	„	0	47	·3633	
500	Sini	22	47	0	85	56	50	30	57		0	30	·3748	
500	Do.		...			...		30	55		0	30	·3751	
518	Katarnian Ghat	28	19	50	81	7	50	41	16	„	1	42	·3445	
518	Do.		...			...		41	11	„	1	43	·3445	
530	Bettiah	26	48	50	84	31	30	38	39	„	1	17	·3543	
530	Do.		...			...		38	40	„	1	15	·3544	
544	Bāran	25	5	32	76	30	30	36	5	„	1	6	·3522	
544	Do.		...			...		36	6	„	1	6	·3523	
545	Bīna	24	10	50	78	11	0	33	38	„	0	56	·3572	
545	Do.		...			...		33	41	„	0	55	·3573	
557	Indore	22	42	8	75	52	40	31	25	„	0	30	·3679	
557	Do.		...			...		31	24	„	0	30	·3681	
573	Cawnpore	26	27	0	80	21	0	38	4	„	1	22	·3527	
573	Do.		...			...		38	4	„	1	23	·3527	
598	Kāthgodām	29	15	19	79	32	50	42	53	„	2	1	·3371	
598	Do.		...			...		42	53	„	2	2	·3371	
692	Balasore	21	30	30	86	54	40	28	39	„	0	5	·3773	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1914-15—concld.

REPEAT STATIONS—*concld.*

Serial No.	Name of Station.	Latitude. °	′	″	Longitude. °	′	″	Dip. °	′	Declination.	°	′	Horizontal Force. C. G. S.	REMARKS.
692	Balasore . .	...			...			28	36	E	0	6	·3774	H is derived from mean "m" throughout.
699	Berhampur (Ganjām).	19	18	10	84	48	40	24	8	W	0	15	·3824	
699	Do. . .	..			...			24	10	„	0	15	·3823	
710	Cumbum . .	15	35	50	79	6	40	16	48	„	1	10	·3824	
710	Do. . .	...			. .			16	49	„	1	11	·3827	
746	Chānda . .	19	57	50	79	17	40	25	43	E	0	4	·3748	
746	Do. . .	...			...			25	46	„	0	5	·3744	
765	Raipur . .	21	15	50	81	38	20	28	31	„	0	15	·3725	
765	Do. . . .	...			...			28	30	„	0	15	·3728	
779	Amrāoti . .	20	55	30	77	45	50	28	13	W	0	2	·3646	
779	Do. . . .	...			...			28	13	„	0	3	·3650	
831	Sāntāhār . .	24	48	10	88	59	20	34	56	E	0	45	·3683	
831	Do. . .	...			...			34	54	„	0	45	·3682	
871	Lāksām . .	23	15	40	91	7	20	31	56	„	0	23	·3753	
871	Do. . .	...			...			31	56	„	0	24	·3754	
961	Mandalay . .	21	59	50	96	6	30	29	26	„	0	9	·3823	
961	Do. . .	...			...			29	26	„	0	9	·3823	
975	Myitkyinā . .	25	23	20	97	24	10	36	22	„	1	1	·3634	
975	Do. . .	...			...			36	17	„	1	3	·3634	
977	Bhamo . .	24	15	30	97	13	10	33	51	„	0	20	·3748	
977	Do. . .	...			...			33	53	„	0	23	·3749	
1068	Prome . .	18	49	40	95	13	20	22	51	W	0	3	·3908	
1068	Do. . .	...			...			22	52	„	0	3	·3904	
1071	Bassein .	16	46	20	94	44	30	18	16	„	0	8	·3947	
1071	Do. . .	...			...			18	18	„	0	8	·3945	
1195	Moulmein . .	16	29	40	97	37	30	17	44	E	0	2	·3954	
1195	Do. . .	...			...			17	43	„	0	1	·3955	
1338	Barmer . .	25	44	35	71	26	40	37	6	„	1	43	·3433	
1338	Do. . .	...			...			37	6	„	1	41	·3432	
1402	Barrackpore .	22	46	29	88	21	39	31	1	„	0	28	·3745	

OLD STATION REOBSERVED.

Serial No.	Name of Station.	Latitude. °	′	″	Longitude. °	′	″	Dip. °	′	Declination.	°	′	Horizontal Force. C. G. S.	REMARKS.
1331	Mussoorie . .	30	27	12	78	5	10	44	38	E	2	19	·3303	H is derived from mean "m."

NOTE.

The foregoing values of Dip, Declination and Horizontal Force are uncorrected for secular change, diurnal variation, instrumental differences, etc., and are to be considered preliminary values only.

All longitudes are referable to that of the Madras observatory taken at the value of 80° 14′ 54″ east from Greenwich.

At every station, except Karāchi which had previously been well marked, two values of each element are given in the tables, the upper values being those obtained at the sites before they were permanently marked by pillars this season and the lower values being those obtained at the sites after the pillars had been built.

" a " suffixed to a station number against the upper value indicates that it is a new site selected in some previous season and when suffixed to a station number against the lower value indicates that a fresh site has been selected for the pillar built this season.

The values against station No. 1402, Barrackpore, are those obtained at a new repeat station established this season near the Barrackpore observatory which has now been closed.

BASE LINE.

No. 19 PARTY.

PERSONNEL.

Imperial Officers.

Major H. L. Crosthwait, R. E., in charge to 23rd October 1914.

Captain W. E. Perry, R.E., in charge from 24th October 1914 to 31st August 1915.

From 1st to 7th September and again from 24th to 30th September charge was held by the Officer in charge of No. 16 Party in addition to his other duties.

Lieutenant-Colonel C. H. D. Ryder, C.I.E., D.S.O., R.E., in charge from 8th to 23rd September 1915.

Lower Subordinate Service.

1 Computer.

Progress was made with the erection of the Comparators and a motor-generator to transform the alternating current at 220 volts of the public supply to continuous current at 100 volts which is required for the motors and heating arrangements of the Bar Comparator was installed.

No Base Line work could be attempted as no officers were available.

COMPUTING AND TECHNICAL OFFICES.

BY MR. J. DE GRAAFF HUNTER, M.A.

PERSONNEL.

Imperial Officers.

Mr. J. de Graaff Hunter, M.A., in charge.

The services of Lieutenant K. Mason, R.E., were lent for about one month.

Provincial Officer.

Mr. Hanuman Prasad.

Computing Office.

Babu Ishan Chandra Deb, B.A., and eleven computers.

Five computers lent from the field parties for a portion of the year worked in the Computing Office.

Printing Office.

Mr. Sarat Kumar Mukerji, Sub-Assistant Superintendent with 19 compositors, printers, etc.

Workshops.

1 Head Artificer with 8 fitters and carpenters.

Computing Office.

Babu Hem Chandra Banarji, B.A., was confirmed in the Computing Office on the transfer of Babu Dhirendra Nath Saha to the Upper Subordinate Service.

The present season has been quite unusual on account of the curtailment of field work in the parties.

This caused a number of computers from Nos. 13, 14 and 15 Parties to be without full employment in their respective parties. The services of these computers were accordingly placed at my disposal.

Triangulation Charts.—The compilation and publication of triangulation charts were recognised as a very important and also very long piece of work. Proceeding at the rate of the previous season the publication of the 900 charts promised to extend over 20 years. Still it had not previously been possible to employ a larger number of computers on this work. The present season gave opportunities of remedying this and a prospect of getting out the whole series in some two or three years, owing to the larger number of men available for the work. The first necessity was to improve the system on which the charts were produced. The old plan was to obtain all the topo. data from the circles concerned and to complete the G. T. data and such topo. work as was given in the Synoptical volumes at Dehra. This led to great delay as the circles could not always supply complete data at once, and constant reference had to be made to them. Moreover, the data had to be set up in very large pages to print at the side or on the back of the 4 miles=1 inch charts. This was very troublesome for the Printing Office. The size of type used had

to be varied according to the amount of data available, and in some cases sufficient room was not available even when the smallest type was used.

These difficulties have been largely overcome by printing the data in the form of pamphlets, and in printing the portion available at Dehra independently of the modern topo. data available from the circles. The pamphlets recognise three classes :—(1) Geodetic triangulation, (2) Minor triangulation, (3) Intersected points.

(1) Geodetic triangulation, comprising both principal and secondary triangulation *which has been computed rigorously.* Some old triangulation observed as secondary, had been computed without taking account of spherical excess—a plan which inevitably leads to accumulation of azimuthal errors and inconsistencies between azimuths and co-ordinates. Such triangulation could not rightly be classed as geodetic unless its recomputation was effected. Principal and secondary triangulations were classed together, because it was found that some good secondary was better than the less accurate principal. In this connection it is to be remembered that the triangulation series under review date from 1831.

A criterion of strength of triangulation has been adopted from which an estimate of the relative strengths of the several series is possible. This criterion takes account of the mean triangular error, the nature of the figures (whether simple triangles or braced figures) and the average length of side; and the characteristic quantity M is proportional to the probable displacement of a point from its true position after the triangulation has proceeded a given distance. The following table gives the values of M and some other particulars for the geodetic triangulation of India.

T

The Series of the G. T. S. Triangulation in India and Burma, arranged in chronological order.

The following notation is used:—

Δ = triangular error, n = number of triangles in a Series, $m=\sqrt{\Sigma\Delta^2/3n}$, $M=(1+f)m\sqrt{18/l}$ where $f=\frac{1}{12}\cdot\frac{2\alpha+\gamma}{\alpha+\beta+\gamma+\delta}$ and α, β, γ, δ are the numbers of triangles, quadrilaterals, pentagons and higher odd-sided figures, hexagons and higher even-sided figures respectively.

The average length of side for any Series is l (miles) and the average for all the Series up to No. 90 is 18 miles.

No.	Name of Series.	Season.	± m	l	Number of Independent Figures. 3 Sided.	4 Sided.	5 Sided.	6 Sided.	7 Sided.	8 Sided.	9 Sided.	10 Sided.	11 Sided.	12 Sided.	Compound.	± M	Order of Merit.	Reference number of instrument used (see table on page 143).	Synoptical Volume.
1	South Pārasnāth Merdl.	1831-39	3·308	24·0	6	...	...	...	...	...	...	...	...	...	2	3·26	92	47	XIIIA
2	Budhon Merdl.	1833-43	2·242	19·2	25	1	2	4	...	...	...	...	...	...	...	2·46	86	5, 46, 50, 52	XIV
3	*Amua Merdl.*	1834-38	1·647	18·9	34	...	...	...	...	...	...	...	...	...	...	1·88	77	4, 5	XVI
4	*Rangīr Merdl.*	1834-64	1·643	20·6	31, §1	...	...	...	...	...	...	...	...	...	...	1·79	72	1, 48, 49, 53	XV
5	*Calcutta Longl.*	1834-69	0·369	26·6	...	...	4	2	2	2	1	1	1	...	...	0·32	8b	1, 2, 4, 42, 44, 50, 53	XII
6	*Great Arc Merdl. Sec. 24°-30°*	1835-66	0·708	22·2	10	...	2	2	...	...	...	...	...	1	4	0·71	36b	1, 3, 41, 44, 45, 50	II
7	*Bombay Longl.*	1837-63	0·844	27·6	1	1	2	2	...	...	...	...	...	...	2	0·74	38	43, 51	XXVI
8	*Great Arc Merdl. Sec. 18°-24°*	1838-41	0·567	21·3	17	3	4	...	...	1	...	...	...	...	3	0·59	28b	1, 41	VIII
9	*Great Arc Merdl. Sec. 8°-18°*	1840-74	0·390	23·7	1	4	2	5	3	1	...	...	...	...	3	0·36	13b	1, 2, 43	XXIX
10	*Singi Merdl.*	1842-62	1·187	24·9	18	3	...	...	...	...	...	...	...	...	2	1·14	51	4, 5, 51	XXXII
11	*South Konkan Coast*	1842-67	2·176	29·6	16	3	...	...	...	...	...	...	...	...	...	1·93	79	43, 51	XXIII
12	*Karāra Merdl.*	1843-45	1·507	16·4	21	1, ‖1	...	...	...	...	...	...	...	1	...	1·81	73	4, 46, 49, 52	XVI
13	*North Maluncha Merdl.*	1844-46	1·266	18·4	6	...	...	1	2	...	...	...	...	...	...	1·42	60	4, 50	XIX
14	*Chendwār Merdl.*	1844-69	0·841	15·1	17	1	1	1	...	...	...	...	...	...	...	1·06	45	4, 5, 41, 44	XVIII
15	*Gora Merdl.*	1845-47	0·978	15·6	23	...	...	...	...	...	...	...	...	...	1	1·21	52b	52	XVII
16	*Calcutta Merdl.*	1845-48	1·173	8·5	45	...	...	...	...	...	...	...	...	...	...	1·99	82	4	XX
17	South Maluncha Merdl.	1845-53	1·606	15·7	11	2	...	...	...	...	...	...	...	...	...	1·97	81	2, 5	XIIIA

18	*Khânpisura Merdl.*	1845-62	1·227	27·3	...	4	1	1	2	...	...	...	...	...	1	1·07	46	43, 51	XXXI
19	*Gurwāni Merdl.*	1846-47	1·165	13·8	32	...	...	...	...	...	...	...	...	...	...	1·55	65	44, 46	XVII
20	*North-East Longl.*	1846-55	0·446	11·1	96	2	1	3	...	1	...	...	...	...	...	0·65	31*b*	1, 3, 41, 42, 44, 45, 50	XXXV
21	*Hurilāong Merdl.*	1848-52	1·502	14·3	20	...	...	1	...	...	...	...	...	...	1	1·92	78	4, 5, 43	XVIII
22	*North-West Himālaya*	1848-53	0·641	25·3	...	6	1	2	...	...	...	...	...	...	3	0·55	26	3, 44, 45	VII
23	*Gurhāgarh Merdl.*	1848-62	0·914	13·6	70	...	1	2	...	1	...	...	...	...	1	1·21	52*b*	4, 44, 51	IV
24	*East Coast*	1848-63	0·608	16·9	22	6	...	3	...	1	...	...	...	...	2	0·70	34*b*	2, 5, 42, 43	XIII
25	*Karāchi Longl.*	1849-53	0·558	15·8	...	10	2	10	2	2	...	...	...	...	1	0·60	30	1	III
26	*Abu Merdl.*	1851-52	0·617	15·9	1	...	...	3	...	...	...	...	...	...	...	0·68	33	5	XXX
27	*North Pārasnāth Merdl.*	1851-52	0·895	12·6	20	...	...	...	...	...	...	...	...	...	...	1·25	54	42	XIX
28	*Kāthiāwār Merdl.*	1852-56	0·990	17·4	7	3	1	1	...	...	...	...	...	...	3	1·11	49	5	XXXIV
29	*Gujarāt Longl.*	1852-62	0·859	14·2	31	...	2	...	...	...	...	...	...	...	...	1·12	50	5	XXX
30	Kāthiāwār Minor Longl.	1853	1·481	23·1	1	5	...	...	...	...	...	...	...	...	...	1·34	58	5	XXXIV
31	Sābarmatī Secondary	1853-54	1·348	5·3	15	2	...	...	...	...	...	...	...	...	...	2·84	88	5	XXX
32	*Great Indus*	1853-61	0·359	12·7	...	9	1	12	2	2	...	3	...	1	...	0·43	20*b*	1, 3, 44	I
33	*Rahūn Merdl.*	1853-63	0·327	14·1	...	2	...	15	2	...	...	...	...	...	...	0·37	15*t*	44	V
34	*Assam Longl.*	1854-60	0·579	12·5	...	2	3	4	...	1	...	...	...	...	...	0·71	36*b*	42, 43, 45	XXII
35	*Cutch Coast*	1855-58	0·986	12·5	...	5	6	...	...	1	...	...	...	...	1	1·27	55*b*	5	XXXIII
36	Kashmīr Principal	1855-60	0·884	19·2	...	18	1	1	...	...	...	...	...	...	...	0·86	39	6, 9	VII
37	*Jogī-Tīla Merdl.*	1855-63	0·481	12·3	...	...	...	7	1	1	...	...	...	...	...	0·59	28*b*	1, 3, 41	VI
38	Sambalpur Longl.	1856-57	0·806	19·3	7	2	...	1	...	...	...	...	...	...	...	0·87	40	6	XIII
39	(Cutch) Coast Line Secondary	1856-60	0·975	10·8	33	...	...	...	...	...	...	...	...	...	...	1·47	61	4, 5, 13, 14	XXXIII
40	Kāthiāwār Minor Merdl. No. 1	1858-59	0·930	9·1	13	1	...	...	...	...	...	...	...	...	...	1·51	64	5	XXXIV
41	Kāthiāwār Minor Merdl. No. 2	1859-60	1·247	12·1	14	1	...	...	...	...	...	...	...	...	1	1·75	70	5	XXXIV
42	Kāthiāwār Minor Merdl. No. 3	1859-60	0·969	10·0	17	3	1	...	...	...	...	...	...	...	...	1·48	62	5	XXXIV XXX
43	*Bider Longl.*	1859-72	0·311	22·0	...	1, ‖1	2	1	...	3	...	...	...	...	1	0·30	5*b*	1, 42, 43	X

§ Centred triangle. ‖ Centred quadrilateral.

T 2

The Series of the G. T. S. Triangulation in India and Burma, arranged in chronological order—contd.

No.	Name of Series.	Season.	± m	l	Number of Independent Figures. 3 Sided.	4 Sided.	5 Sided.	6 Sided.	7 Sided.	8 Sided.	9 Sided.	10 Sided.	11 Sided.	12 Sided.	Compound.	± M	Order of Merit.	Instrument used (see table on page 143).	Synoptical Volume.
44	*Eastern Frontier Sec. 23°-26°*	1860-64	0·409	13·2	...	6	2	1	1	...	1	...	...	1	...	0·49	23b	42	XXI
45	*Sutlej Merdl.*	1861-63	0·346	10·6	50	...	...	...	...	...	...	...	...	...	...	0·53	25	1	VI
46	*Madras Merdl. and Coast*	1861-68	0·426	21·6	...	3	2	6	8	2	...	...	...	...	...	0·40	19	1, 2, 43	XXVIII
47	Kāthiāwār Minor Merdl. No. 4	1863-64	1·154	10·8	14	...	...	...	...	...	...	...	...	...	1	1·73	69	5	{ XXXIV XXX
48	*East Calcutta Longl.*	1863-69	0·379	10·7	32	...	...	2	...	...	...	...	...	...	...	0·57	27	3	XXI
49	*Mangalore Merdl.*	1863-73	0·440	20·7	1	1	1	4	2	...	...	...	...	...	2	0·45	22	2, 42, 43	XXIV
50	Kumaun and Garhwāl	1864-65	1·742	26·7	2	4	...	1	...	...	...	...	...	...	...	1·50	63	11, 12, 19, 20, 53	XXXV
51	Nāsik Secondary	1864-66	2·033	10·5	26	...	...	...	...	...	...	...	...	...	...	3·12	91	9, 33, 34	XXXII
52	Burma Coast Sec. 11°-23°	1864-82	0·380	19·8	14	18	5	5	1	2	...	...	...	...	4	0·39	18	44	...
53	*Jabalpur Merdl.*	1865-67	0·340	22·4	...	2	...	7	1	...	...	...	...	...	...	0·31	7	1	IX
54	*Madras Longl.*	1865-80	0·384	21·4	1	1	3	6	...	...	...	...	...	...	...	0·37	15t	2, 43	XXVII
55	Assam Valley Triangulation	1867-78	1·690	9·5	46	5, ‖3	1	...	...	...	...	...	...	...	...	2·65	87	7, 8, 18, 25, 54	XXII
56	*Brahmaputra Merdl.*	1868-74	0·564	12·0	...	...	1	6	...	1	...	...	...	...	1	0·70	34b	3	XX
57	Coimbatore Minor No. 1	1869-71	1·547	13·6	19	...	1	...	...	...	...	...	...	...	...	2·07	83	6, 8, 26	XXIX
58	*Bilāspur Merdl.*	1869-73	0·302	15·7	...	6	4	6	...	...	...	...	...	...	...	0·33	11	1, 44	XI
59	Cuddapah Minor	1871-72	0·826	17·6	8	1	...	...	...	...	...	...	...	...	...	0·96	42t	24	{ XXIX XXVIII
60	Hyderābād Minor	1871-72	1·405	19·9	9	...	...	...	...	...	...	...	...	...	...	1·56	66	32, 43	XXIX
61	Malabar Coast	1871, 74, 80	1·532	17·4	12	...	...	...	...	...	...	...	...	...	...	1·82	74	8, 21	{ XXIX XXVII
62	Jodhpore Merdl.	1873-76	0·291	15·6	...	3	1	7	1	...	1	...	...	...	...	0·32	8t	43	VIIA
63	*South East Coast*	1875-79	0·522	11·7	...	8	...	11	2	...	...	...	...	...	1	0·65	31b	2	XXV
64	Eastern Sind Merdl.	1876-81	0·244	13·0	...	3	2	5	2	...	...	...	...	...	...	0·30	5b	2, 43	VIIA

65	Siam Branch Triangulation	1878-81	3·711	16·1	7	4	...	...	...	...	...	...	...	...	1	4·34	94	22	...
66	Mandalay Merdl.	1889-95	0·418	27·0	...	13, ‖3	...	...	...	...	...	...	...		1	0·35	12	13, 14, 18, 23	...
67	Mong Hsat Secondary	1891-93	3·054	24·0	9	1	...	...	...	...	...	...	...	...	1	3·01	89b	10, 14, 24	...
68	Manipur Longl.	1894-99	0·453	28·4	...	5, ‖2	...	...	...	...	...	...	...	...	...	0·36	13b	13, 14, 15	...
69	Makrān Longl.	1895-97	0·285	23·9	2	2, ‖1	1	...	...	...	...	...	...	...	...	0·26	4	13, 14	...
70	Mandalay Longl.	1899-1909	1·696	17·2	8	2	1	...	...	...	...	...	...	...	...	1·96	80	27	...
71	Manipur Merdl.	1899-1902	0·884	20·9	30	‖1	...	...	...	...	...	...	...	...	...	0·96	42t	14, 15	...
72	Great Salween	1900-11	0·404	32·6	...	2, ‖4	2	...	...	...	...	...	...	...	1	0·82	8t	14, 15, 16	...
73	Kidarkanta Secondary	1902-03	1·323	15·2	3	1	...	...	...	...	...	...	...	...	...	1·62	67	14, 15	XXXV
74	Kalat Longl.	1904-08	0·365	39·7	...	6, ‖5	...	1	...	...	...	...	...	...	...	0·25	3	14, 15	...
75	Baluchistān Triangulation	1908-09	1·348	33·2	...	1	...	...	...	...	...	...	...	...	1	1·08	47b	16, 55	...
76	North Baluchistān	1908-10	0·221	32·7	...	5, ‖3	1	...	...	...	...	...	...	...	...	0·17	1	14, 16, 55	...
77	Gilgit	1909-11	0·443	31·6	5	3, ‖1	...	...	...	...	...	...	...	...	...	0·37	15t	14, 16, 17, 27	...
78	Khāsi Hills Secondary	1909-11	2·038	10·7	14	3	...	...	...	...	...	...	...	...	...	3·01	89b	27, 29, 30, 31	...
79	Mawkmai Secondary	1909-11	1·576	10·9	41	1	...	...	...	...	...	...	...	...	...	2·35	85	29, 30, 35, 56	...
80	Upper Irrawaddy	1909-11	0·596	30·6	4	5	...	...	...	...	...	...	...	...	...	0·49	23b	15, 57	...
81	Jaintiā Hills Secondary	1910-11	0·986	6·9	23	...	...	...	...	...	...	...	...	...	...	1·86	76	27, 31	...
82	Bhīr Secondary	1911-12	0·794	17·4	24	...	...	...	...	...	...	...	...	...	...	0·94	41	30	...
83	Rānchi Secondary	1911-12	1·840	15·2	13	...	...	...	...	...	...	...	...	...	...	2·34	84	28, 55	...
84	Villupurām Secondary	1911-12	1·184	10·9	18	...	...	...	...	...	...	...	...	...	...	1·78	71	29	...
85	Sambalpur Merdl.	1911-14	0·250	2·57	...	6, ‖4	1	1	...	...	...	...	...	...	...	0·21	2	17	...
86	Indo-Russian Connection	1912-13	2·790	10·9	11	7, ‖2	...	..	...	...	...	...	...	...	...	3·92	93	36, 37, 38, 39, 40	...
87	Khandwā Secondary	1912-13	0·999	15·2	22	...	...	...	...	...	...	...	...	...	...	1·27	55b	30	...
88	Ashta Secondary	1913-15	1·048	15·3	21	...	...	...	...	...	...	...	...	...	...	1·33	57	30, 29	...
89	Buldāna Secondary (incomplete)	1913-14	0·304	12·3	18	...	...	...	...	...	...	...	...	...	...	0·43	20b	29	...

‖ Centred quadrilateral.

The Series of the G. T. S. Triangulation in India and Burma, arranged in chronological order—concld.

No.	Name of Series.	Season.	± m	l	Number of Independent Figures. 3 Sided.	4 Sided.	5 Sided.	6 Sided.	7 Sided.	8 Sided.	9 Sided.	10 Sided.	11 Sided.	12 Sided.	Compound.	± M	Order of Merit.	Instrument used (*see* table below).	Synoptical Volume.
90	Naldrug Secondary	1913-14	0·465	15·2	27	1	...	...	...	...	...	...	...	...	...	1·85	75	27	...
91	Nāgā Hills Secondary . . .	1913-14	0·913	21·3	7	1	1	...	...	...	...	...	...	...	...	0·96	42*t*	15	...
92	Middle Godāvari Secondary . .	1914-15	0·913	17·1	14	1	...	...	...	...	...	...	...	...	...	1·08	47*b*	29	...
93	Kohīmā Secondary	1914-15	1·094	15·0	13	...	...	...	...	...	...	...	...	...	...	1·39	59	15, 55	...
94	Cāchār (incomplete)	1914-15	1·077	10·5	10	...	...	...	...	...	...	...	...	...	...	1·65	68	15	...

For 42 Series entering the Simultaneous Grinding (shown in italics above) $\Sigma M^2 = 45{\cdot}3591$. Mean Square $M = \pm\sqrt{\frac{45{\cdot}3591}{42}} = \pm 1{\cdot}04$.

For Series up to No. 94 $\sum_{1}^{94} M^2 = 214{\cdot}3199$. Mean Square $M = \pm\sqrt{\frac{214{\cdot}3199}{94}} = \pm 1{\cdot}51$.

Reference numbers of instruments used.

*1	Troughton & Simm's	36" No.	...
*2	,, ,, ,,	24	1
*3	,, ,, ,,	24	2
*4	,, ,, ,,	18	1
*5	,, ,, ,,	18	2
6	,, ,, ,,	14	1
7	,, ,, ,,	14	2
8	,, ,, ,,	14	3
9	,, ,, ,,	14	5
10	,, ,, ,,	14	7

11	Troughton & Simm's	14" No.	8
12	,, ,, ,,	14	12
13	,, ,, ,,	12	I
14	,, ,, ,,	12	II
15	,, ,, ,,	12	III
16	,, ,, ,,	12	IV
17	,, ,, ,,	12	V
18	,, ,, ,,	12	11
19	,, ,, ,,	12	12
20	,, ,, ,,	12	44

21	Troughton & Simm's	12" No.	183
22	,, ,, ,,	12	644
23	,, ,, ,,	12	A/1888
24	,, ,, ,,	10	102
25	,, ,, ,,	10	417
26	,, ,, ,,	8	48
27	,, ,, ,,	8	956
28	,, ,, ,,	8	1055
29	,, ,, ,,	8	1311
30	,, ,, ,,	8	1315

31	Troughton & Simm's	8" No.	1316
32	,, ,, ,,	7	87
33	,, ,, ,,	6	709
34	,, ,, ,,	6	710
35	,, ,, ,,	6	877
36	,, ,, ,,	6	1099
37	,, ,, ,,	6	1100
38	,, ,, ,,	6	1383
39	,, ,, ,,	6	1403
40	,, ,, ,,	6	1404

*41	Barrow's	36" No.	...
*42	,,	24	1
*43	,,	24	2
*44	Colonel Waugh's	24	1
*45	,,	24	2
*46	Saiyad Mir Mohsin's	18	...
*47	Cary's	18	G
*48	,,	18	L
*49	,,	18	M. O.
*50	,,	15	...

*51	Dollond's	15" No.	...
*52	Harris' and Barrow's	15	...
53	Thomas Cooke and Son's	12	57
54	,, ,, ,,	10	190
55	,, ,, ,,	8	10163
56	,, ,, ,,	8	10165
57	,, ,, ,,	6	1372

* For history and description of this instrument *see* Appendix 2 of G. T. S. Vol. II.

For simplification of reference and of the G. T. S. index chart it has been decided to refer to the several series by numbers. These numbers give the chronological order in which the series were commenced. The values of M for the series occurring in each pamphlet are given after the preface.

In addition to stations of geodetic triangulation, all other geodetic stations other than bench-marks are briefly referred to in the pamphlets. It was thought that this would add to the usefulness of the pamphlets to Trigonometrical parties without materially increasing their bulk. Moreover, any topographical officer coming across a geodetic station of any kind would have some particulars of it and be in a better position to report on its state of repair and advise any necessary action.

(2) Minor triangulation, comprising the ordinary topographical triangulation together with work of a minor kind such as used to be executed by the old trigonometrical parties in connection with the geodetic triangulation.

(3) Intersected points. These are distinguished according as they have been fixed from geodetic or minor stations. If a point was well marked by a heliotrope and observed with a large theodolite its accuracy of fixing may approximate to that of a geodetic station and exceed that of a topographical station. The co-ordinates of intersected points are accordingly given to such accuracy as appears justifiable in each case.

Of the above both geodetic and minor triangulations are given in one list and the geodetic stations precede the minor. It is intended, however, when further triangulation of either kind becomes available, to put this in at the end of the list no matter whether it be geodetic or minor. Only the last page will be reprinted, the original data contained in it being followed by the new data available, for substitution for the last page of this portion of the existing pamphlet. The same applies to the intersected points which occur in a separate list and with independent pagination. In this way it is hoped to keep the pamphlets up to date without constant reprints of whole pamphlets.

The pamphlets are now provided with an index and it is proposed to re-print this and issue with each addendum.

The present procedure is for the data to be compiled in Dehra and sent to the Printing Office. A fully corrected proof is then handed to the Drawing Office from which the chart is drawn. The development of what has been indicated above took some months and cannot be said to have come properly into force until July. The increase in rate of production is now beginning to be felt and it is hoped that an average rate of four or five pamphlets a week will be attained in the near future.

Adjustment of Burma Triangulation.—A fact which appears only to have been recognised in the last year is that triangulation pamphlets cannot be published until all triangulation, in the area with which they deal, has been adjusted. If this has not been done two sets of values of co-ordinates for the same point occur. This drew attention to the case of the Burma triangulation and the smaller cases of Baluchistān and Kashmīr. The Burma triangulation had not been adjusted because the entire network contemplated had not been completed. The labour of adjustment on the plan on which the Indian network was adjusted also proved a formidable obstacle. However, some preliminary adjustment seemed essential so as to arrive at data everywhere consistent *inter se:* and the best method of arriving at this was considered. In this way a much simplified method of adjustment was arrived at. This method lacks some

of the theoretical rigidity of detail which characterised the old plan: but it is doubtful whether the results will differ by an amount which is of any importance even for the most refined geodetic considerations. At least it supplies a working method which is practicable from the point of view of labour involved. As further triangulation series are completed it will be possible to reopen the work and give further corrections if this is then considered desirable. To test the method (which is founded on the theory of probability even as the older method was) the Baluchistān triangulation was adjusted. Taking into account the novelty of the method this was effected by a pair of computers in a satisfactorily short time. A good deal of preliminary work for the Burma triangulation has been done, but further progress with this is stopped for a few months owing to the fact that one triangle in Burma has to be re-observed. It is expected that this will be done in December 1915: and if so, the complete adjustment of the triangulation should be completed by four computers within six or eight months. Until that time publication of Burma pamphlets will be held up: but great progress with the Indian pamphlets will have been made, and the Burma pamphlets will then be able to be taken up with energy.

Levelling.—Dynamic and orthometric heights have been completed of 9 levelling lines, namely, (1) Rāwalpindi to Murree, (2) Srīnagar to Islāmābād, (3) Akhaurā to Dacca and Pāchuriā, (4) Porādaha to Farīdpur, (5) Comilla to Chittagong, (6) Farīdpur to Barisāl, (7) Meerut to Delhi, (8) Thazi to Prome and Rangoon, (9) Elephant Point (Rangoon) to Pyinmanā and Thazi. All the published heights in Burma have hitherto been referred to Elephant Point (Pilakat Creek) sea level; but the levelling has recently been carried to Amherst, and shows that the Elephant Point sea level is higher than that at Amherst by 0·785 foot. It has been decided to refer all heights in Burma to Amherst mean sea level in future, since the Amherst Tidal Observatory is situated on an open coast, while that at Elephant Point is two miles up the Rangoon river. At the same time the results have been expressed in orthometric heights.

The Assam levelling circuit from Pārvatīpur *via* Gauhāti, Karīmganj, Akhaurā, Dacca, and Pāchuriā to Porādaha has a closing error of 1·005 feet, which is being distributed among the four last river crossings. Another levelling circuit, namely, Rangoon, Pyinmanā, Thazi, Magwe, Taungdwingyi, Prome and Rangoon, is found to have a closing error of 0·269 foot in a distance of 883 miles.

Press work.—The Tibetan explorations which form Records of the Survey of India, Volume VIII, and extend to 411 pages have been prepared for press and all proofs read.

All proofs of Professional Paper No. 15 of 190 pages have been read in the Computing Office.

Research.—In 1912 an attempt was made to solve the question of the effect on the triangulation of India of changing the spheroid of reference. The Everest spheroid differs from the spheroid derivable from most recent work, the semi major and minor axes being too small by about 900 and 700 metres respectively. What was wanted was a ready means of changing to any desired spheroid: or even of treating the axes of the spheroid and the co-ordinates of the origin as unknown and determining them so as best to fit the geodetic results accumulated by observations. This problem has now been solved satisfactorily, and the results are given in the first four chapters of Professional Paper No. 16 entitled "The Earth's Axes and Triangulation." The Paper has

been printed to this extent. A number of related matters remain to be dealt with in the later chapters. This paves the way for the general consideration of the Indian deflections, a problem the solution of which will be much assisted by the use of an instrument which has been recently designed. This instrument performs the integrations

$$\int \frac{\text{Sin } \phi \text{ dr}}{\sqrt{r^2+h^2}} \text{ and } \int \frac{\text{Cos } \phi \text{ dr}}{\sqrt{r^2+h^2}}$$

(r, ϕ, being polar co-ordinates of any point referred to station and h the height) by simply running the pointer round the contours of a map. If ϕ is measured from the prime vertical these two integrals multiplied by a suitable constant, are the deflections in seconds of arc, in prime vertical and meridian respectively. They are recorded at one operation on two drums similar to the recording arrangements on a planimeter.

We have now reached a stage when the interpretation of the geodetic results of observations in India on the direction of the plumb-line has become a matter of scientific urgency. The labour of calculating the effect of the attraction of topographical features on the plumb-line is of prodigious amount. To test a theory such as that of Hayford's isostasy, numerous heavy calculations have been necessary. Moreover, these calculations have had to be made with serious limitations to make them practically possible. As an example it has been necessary to treat land and water masses together, though much advantage would accrue if these could be treated separately. The instrument solves this problem when its pointer is caused to travel round the map-contours in the same way that a planimeter is used for evaluating an area. By its means the earth may be divided in any way desired and the effects of each portion separately found without any additional labour. This makes it possible to make different assumptions regarding the state of compensation of different districts. It seems a natural inference that compensation will occur to varying extents and depths in districts whose mode of formation was essentially different geologically. A mountain formed by vertical uplift is not likely to be compensated in the same way or to the same degree as one which is the result of the crumpling of the crust. Mountains of much earlier origin may date from the time of solidification of the crust and so differ from both of these. In fact it is advantageous to study the earth district by district. The instrument will allow this to be done and tables to be produced which will give the effect of any such district at any point. When this has been done, the combined effect of all districts may be considered and the unknown quantities which are connected with each may be determined by the help of equations formed from the observation data. The problem will still remain laborious enough, but it will be possible to consider it in a form which was previously quite impracticable on account of the vast amount of computation labour involved.

Accommodation and Equipment.—About a year ago a large room was given up to the Computing Office which had been vacated by the Drawing Office. This has for the first time for years given space sufficient for the Computing Office and its large bulk of records and stock. During the past year the racks have been improved and added to and a start will shortly be made with a card index for the whole of these. Owing to the cramped state previously existing no sort of order was possible and the discovery of a particular book of records depended largely on the memory of the computers. With good progress it will be possible to report the conclusion of this work in the Records of next year.

A gold blocking press has recently been acquired. This will enable Professional Papers and Volumes to be published from Dehra in much improved form.

Type-Printing Office.

During the year the volume of Tibetan explorations (Volume VIII of the Records) in two parts (411 pages) and Professional Paper No. 15 (190 pages) have been finished. Professional Paper No. 16 has been printed up to page 68. At present 10 compositors are steadily engaged on triangulation pamphlets. A reprint of the graticule tables for maps has been begun. Tables of logarithmic sines, cosines, tangents and cotangents for every minute, to 5 places of decimals, have been printed and stereotyped. These will be of use in traverse computations. It is intended to revise and stereotype all tables of the Auxiliary Tables.

Workshops.

The increase in work in the Workshops has made some changes and additions immediately compulsory. A lean-to shed 36 × 18 feet has been added on the south wall to afford protection to the carpenters and to timber during the rains. This has proved most valuable. It was also noticed that the arches and pillars which very much obstructed the existing building could be removed. These arches supported the roof of the original buildings: but a roof which was subsequently built did not rest on them. They have accordingly been removed. It is proposed to use the building as a godown when the workshops vacate it, and the clearance of these arches will much improve its capacity for this purpose. A 6 H. P. electric motor has been acquired and installed. Electric current has only become available during this year, so that previously no power was available. A circular saw and emery wheel have been obtained and these, as well as three lathes and a routing machine (specially for stereo-plates but also of general use), are now all driven by the motor. Although this new arrangement has only very recently been completed the great advantages of it are daily apparent. A good deal of construction and general equipment work for the offices has been carried out.

The construction of the integrator referred to under "Research" has been begun and it is hoped that it will be completed during the present year.

A new optical device has been made and experimented with. This aims at replacing heliotropes for certain purposes. Experiments up to date have resulted in this arrangement being visible up to 4½ miles, and it is hoped that this distance will be considerably increased.

A Traverse signal (*vide* photograph and drawing) of which several have been made in the workshops may be described here. It was primarily designed for the Bombay City Survey, 1911, in which it was used successfully. It is the device referred to on page 47 of Records of the Survey India, Volume V. The marks defining the traverse stations were about one foot below ground level, and consequently it was difficult to centre an instrument or signal accurately over them. The signal is supported by a three-legged stand about 20 inches high, the top of which is a ring (shown in plan in the sketch at A A) whose inner diameter is 9″. An iron tube shown in section at

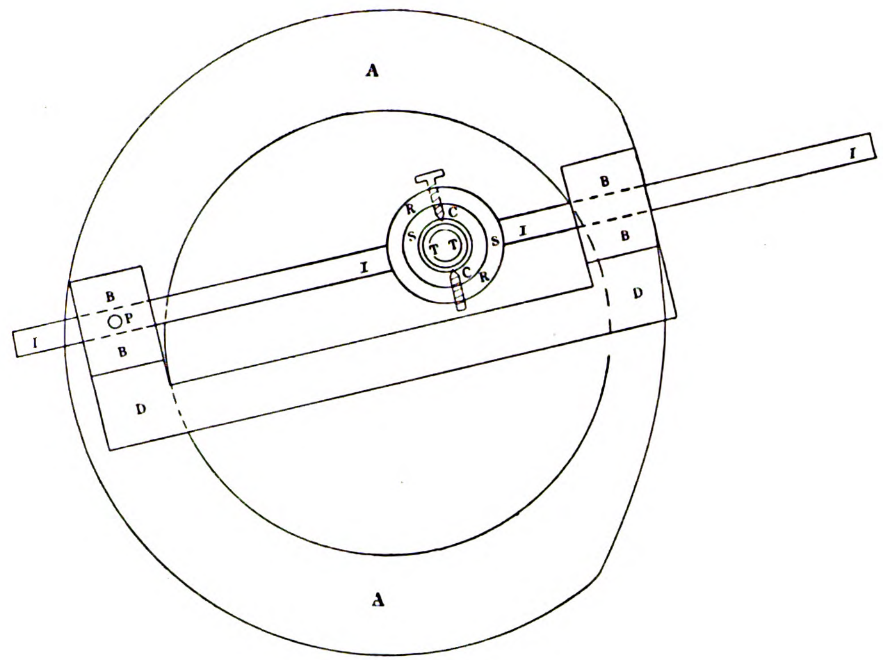
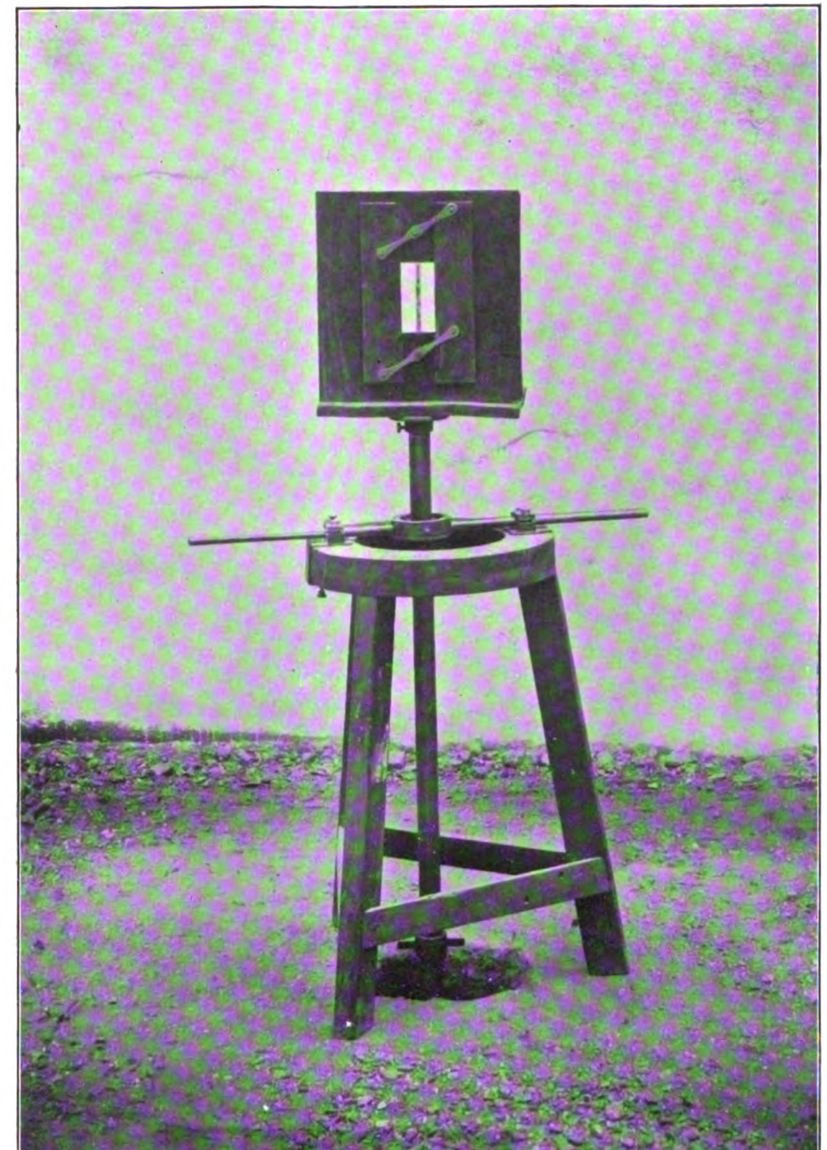


Diagram of TRAVERSE SIGNAL: about half size



Traverse Signal designed by Mr. J. de Graaff Hunter, M.A., for the Bombay City Survey.

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1916.

T T, whose lower end rests on the mark, passes through the ring. The lower end of the tube is fitted with a socket, the whole being turned up true in a lathe; and the socket fits into the mark, which is made cup-shaped, and automatically centres itself. It is accordingly necessary to arrange a means of holding the tube and having adjustments for making it vertical. A brass sleeve, S S in section, with a clamping device slides on the rod. This sleeve is supported on two centres C C at the ends of one diameter of a brass ring R R. The diameter of the ring at right angles to this is continued outwards by two iron rods I I turned up true, which slide in two brass bearings B B, and the rods can be clamped in any desired position. The bearings themselves are fixed on a plate D D which is pivoted at one end with a clamp at the other end. When unclamped this is free to turn about a vertical axis P, giving a motion at right angles to that obtained by sliding the rods in their bearings. A combination of the two motions is sufficient to permit the tube to be brought into a vertical position. This is readily effected with the help of the indications of a spirit level attached to the tube. The tube is free to rotate on its own axis, so that the level soon shows when verticality has been obtained. This accomplished, the clamp screws are made fast. It is not necessary for the ground on which the tripod stands to be approximately level. A small table is fitted to the top of the vertical tube and a vertical board is attached to this in such a position that the axis of the tube just grazes its front face. In this board an opening is cut about 4 inches square, across which and in line with the tube-axis a strip of brass $\frac{3}{8}$ inch wide is mounted in such a manner that it can rotate on a vertical axis. It is painted black and forms a good object for intersection against a white background of card-board. Its apparent width can be varied by rotating it until it forms a suitably fine line for the particular distance from which it is being observed. For night observation a lamp is placed behind the vertical board and the opening in the board is more or less obscured by a pair of wood strips connected by two brass pieces in the manner of the ordinary parallel rulers, the centre of each brass piece being pivoted on screws fixed in the vertical board. By this means the width of this slit can be varied from nothing to about 3 inches, and its centre is always in the continuation of the axis of the vertical rod. The table also carries the level by means of which the tube is made truly vertical and the brass strip or wooden slit accordingly brought directly over the station mark.

This suffices for the angular measures. For chain measurements a —O— shaped piece is fitted on the rod with freedom to slide up and down unless clamped, but only in such a plane that it is at right angles to the line of sight, which is aligned on the observing telescopes. This is brought to ground level and measurements are made to the extensions on each side.

A similar centreing device is used to transfer the marks to above ground level to permit of the theodolite being centred over the mark.

It has latterly been found that the apparatus may be modified without difficulty to suit the case of any station mark below, at, or above ground level. The only modification required is in the length of the tube and tripod. For some purposes the superstructure may be replaced by a smaller arrangement carrying only the level, the tube itself being used as the object for intersection. The length may be added to by extra pieces screwed on to it.

U 2

Omori Seismograph.

The Omori seismograph has been working throughout the year and the following table gives a statement of the earthquakes recorded.

List of earthquakes recorded from the 1st October 1914 to 30th September 1915.

No.	Date.	Time of beginning, Indian Standard Time, Dehra. H.	M.	Simla. H.	M.	Distance of Epicentre in miles, Dehra.	Simla.	Duration. H.	M.	Intensity.	Remarks and identification with any definitely ascertained earthquake.
		H.	M.	H.	M.	Miles.	Miles.	H.	M.		
1	3rd October 1914	23	14	...		10,000	...	1	26	Very slight.	
2	4th " " .	3	45	3	44	2,700	2,500	1	19	Great intensity.	
3	9th " " .	8	12	8	10	280	100	1	30	Moderate intensity.	
4	12th " " .	21	53½	21	52	1,820	2,000	0	25	Slight intensity.	
5	24th " " .	11	58	11	58	3,500	3,500	1	15	Moderate intensity.	
6	5th November 1914	16	39½	16	39	840	500	0	26	Slight intensity.	
7	25th November 1914.	17	33½	17	33	3,500	4,000	1	20	Considerable intensity.	
8	16th December 1914.	15	53½	15	50	630	500	0	12	Slight intensity.	
9	6th January 1915 .	10	26	10	24	350	300	0	12	" "	
10	" " " .	5	4¾	5	3	2,800	2,000	0	40	Moderate intensity.	
11	14th " " .	12	33	12	31	5,000	4,000 & 5,000	1	6	" "	Italian earthquake of 13th January 1915; very severe.
12	9th February " .	16	34	16	32	850	1,000	0	10	Slight intensity.	
13	22nd " " .	20	28	20	27	840	800	0	20	" "	
14	1st March " .	0	37	0	36	2,800	3,500	0	38	Moderate intensity.	
15	3rd " " .	7	16	7	13	490	250	0	8	Slight intensity.	
16	28th April " .	8	56½	8	57	720	400	0	25	" "	
17	30th " " .	7	8½	...		1,750	...	0	30	" "	
18	2nd May " .	10	43	10	40	3,500	4,000	3	0	Great "	
19	6th " " .	8	49½	8	41	980	1,000	0	18	Slight "	
20	13th " " .	16	23¾	16	25	4,900	5,000	1	17	Moderate "	
21	7th June " .	3	19½	3	19	...	12,000	1	39	" "	
22	31st July " .	7	12	7	12	4,410	4,000	1	30	Considerable intensity.	
23	13th August " .	14	53	14	53	2,800	2,000	0	25	Slight intensity.	
24	7th September 1915.	7	11	7	12	...	...	2	21	Great "	
25	24th September 1915.	13	52½	13	53	3,220	3,000	0	26	Slight "	

PART III.—SPECIAL REPORTS.

Address delivered by COLONEL SIR SIDNEY BURRARD, PRESIDENT, *at the Indian Science Congress at Lucknow on January 13th, 1916.*

THE PLAINS OF NORTHERN INDIA, AND THEIR RELATIONSHIP TO THE HIMĀLAYA MOUNTAINS.*

When I learnt that the Committee of the Indian Science Congress had honoured me by electing me the President for the year and by asking me to give an address to this meeting, I decided to invite the attention of the Congress to the unsolved problems surrounding the formation of mountains. The scientific world is now divided into numerous branches of specialists following their own roads, but the study of mountains belongs to no specialist branch; it is not a road, but a junction of many roads, and geologists and astronomers, physicists and mathematicians, geographers and geodesists, all meet at that junction for discussion. I have approached the question from the roads of geography and geodesy, and I will tell you the lessons I have learnt; I do not, however, ask you to believe that the problems are solved, for although I may be led to place certain geographical and geodetic conclusions before you, I realise that no solution will be satisfactory, unless it proves acceptable to geologists, physicists and mathematicians.

You may think it peculiar that I should be speaking about mountains at a place where only flat plains are to be seen, but I may remind you that to the north of these plains stand the greatest mountains of the Earth, and one of the most interesting of the problems under consideration is, what is the relationship of these plains to those mountains?

This is an outline map of the United Provinces; you will see that these Provinces have three geographical divisions; there is the Himālayan area to the north, there are the level plains in the centre, and there is the ancient table-land on the south.

These great plains in the centre have been formed of loose sediment brought down by the Ganges, Gogrā and other rivers: a borehole was sunk at Lucknow 1,500 feet deep, but no rock bottom was reached.

This is a section across the United Provinces. If you compare the rocky area lying to the south of the plains with that lying to the north, you will find on the south a massive table-land; the geologists have shown that this table-land belongs to a very remote past. The mountains on the north are totally different; here the rocks have undergone continued compression, elevation, and disturbance throughout the tertiary period, and our earthquakes prove that these movements of the Earth's crust in the north of the United Provinces have not yet ceased.

I ask you to consider how does this ancient table-land join on to these younger mountains that are always suffering from movements in the crust?

* The maps and charts referred to in the address were in the form of lantern-slides and have not been reproduced in this report.

If we could dig out from the Gangetic trough all the silt deposited by the Himālayan rivers, what kind of rocky junction should we find under Lucknow?

THE CONTRACTION THEORY.

A hundred years ago the accepted idea was that mountain ranges were due to the upward pressure of liquid lava and that their elevation had been caused by volcanic forces. But when geologists began to study the structure of rocks, they found that mountains had suffered from great horizontal compression, which was evident from the folding of strata. This discovery led to the idea that mountains had been elevated not by vertical forces, but by horizontal forces which squeezed the rock upward. The wrinkling of the Earth's crust into mountains by horizontal forces was explained by the cooling of the Earth: this is the well-known Contraction theory illustrated in this diagram; the Earth's interior is held to cool and to contract, and the outer crust is supposed to get too large for the shrinking core and to wrinkle.

About 1860 the observations of the plumb-line in these Provinces brought to light a most important and totally unexpected fact, namely, that the Himālaya were not exercising an attraction at all commensurate with their bulk.

This instrument is a plumb-line. It is a simple weight suspended on a string, and it hangs under the influence of the attraction of the Earth which pulls it downwards: you know from mechanics, that if one force pulls this weight vertically and if another force pulls it horizontally, the weight will hang in a resultant direction inclined to the vertical. Sixty years ago the question had to be considered, how will a weight hang near the foot of the Himālaya? here there will be two forces; the Earth's mass will be pulling the weight vertically, and the mass of the Himālaya will pull it horizontally. You may think that the mass of the Himālaya is very small compared with that of the Earth; that is true, but we can measure by the stars very small angles of latitude and longitude, and the question was, will the Himālaya deflect the plumb-line sufficiently to affect the observations of the Survey?

The plumb-line was observed at Kaliana, a village near Muzaffarnagar in the United Provinces, 60 miles from the foot of the mountains: the observers found that the Himālaya were exercising no appreciable attraction. Archdeacon Pratt, the mathematician, then calculated from the known dimensions of the Himālayan mass the attraction that the Himālaya should exercise. Geographical exploration has taught us more about the dimensions of the Himālaya and Tibet than Pratt knew, and Major Crosthwait has now revised his actual figures. By the theory of gravitation the plumb-line ought to be deflected at Kaliana 58 seconds towards the hills; it is not deflected at all. It hangs vertically. This discovery was the first contribution made by geodesy to the study of mountains. The discovery was this, that the Himālaya behaved as if they have no mass, as if they were an empty eggshell; they seemed to be made of rock, and yet they exercised no more attraction than air. From the Kaliana observations Pratt deduced his famous theory of mountain compensation: he explained the Kaliana mystery by assuming that the rocks underlying the mountains must be lighter and less dense than those underlying plains and oceans. The visible mountain masses, he said, are compensated by deficiencies of rock underneath them. This is the theory of Mountain

Compensation. The compensation of the Himālaya is not believed now to be exactly complete and perfect: they seem to be compensated to the extent of about 80 per cent.; their total resultant mass is thus about ⅕th only of their visible mass standing above sea-level. The discovery of mountain compensation struck a blow at all theories which attributed the elevation of mountains to any additional masses that had been pushed in from the sides. The elevation of mountains by subterranean lava squeezed in from the side had to be rejected because it gave to mountains additional mass; the wrinkling of the Earth's surface by lateral horizontal forces had to be rejected because it gave to mountains additional mass pushed in from the sides. As the Himālaya possess only ⅕th of their apparent visible mass, I am led to suggest that the principal cause of their elevation has been the vertical expansion of the rocks underlying them, vertical expansion due to physical or chemical change. The name of Pratt and the name of Kaliana have now permanent places in the history of science, and in this city of the United Provinces it is only right that I should recall to you that the great theory of mountain compensation, since found true in every continent, had its origin in the United Provinces, and that its author lies buried in these Provinces at Ghāzīpur.

You will understand from this diagram that if the Earth's interior shrinks and if the outer crust is squeezed up into wrinkles like this, the mountains must possess much additional mass: the theory of compensation forbids such additional mass.

The contraction theory was gradually becoming discredited under the attacks of Fisher, Dutton and others, and it seemed some years ago to be moribund, when it was given a fresh lease of life by the publication and translation into several languages of Professor Suess's great work, *The Face of the Earth.* This work is a critical history of all past geographical, geological and geodetic research; the wealth of its detail, the courtesy of its criticisms have won for Suess's work universal admiration.

But from the geodetic point of view it is disappointing; it accepts the contraction theory in its entirety, and it rejects the theory of Mountain Compensation. Suess does not obscure the issue, as some writers do, by the indefinite adoption of contradictory theories; being quite clear in his own mind he is quite clear to his readers. He states that he does not believe in the compensation of mountains by underlying deficiencies of mass. Now the compensation theory has been found to be true in India, Europe and America: nowhere do mountains attract the plumb-line as the law of gravitation would lead us to expect. So you see that the geodesists are sharply opposed to the school of Suess. Now what is Suess's reason for rejecting the theory of mountain compensation? It is this: he states quite clearly, "mountain compensation is inconsistent with all geological observations." Whilst I admit that mountain compensation is inconsistent with certain geological theories, I do not believe that it is inconsistent with geological observations.

If the Himālaya had the uncompensated mass which they appear to have, and which the school of geologists who follow Suess ascribes to them, they would attract the waters of the Indian Ocean over India; the plains of Northern India would be a great sea; this sea would be 300 feet deep above Allahābād, 400 feet deep above Lucknow and Gorakhpur, and 800 feet deep above Pīlībhīt and Bahraich. Fortunately those mountains have not the power of attracting the Indian Ocean.

MOUNTAIN FLOTATION AND ISOSTASY.

But if the theory of compensation has suffered at the hands of its opponents, it has suffered also from its friends. Pratt's theory of compensation has been stretched into a theory of flotation: an iceberg floats, because ice is lighter than water; an iceberg is compensated in the water by its relative deficiency of density; Sir George Airy, the Astronomer Royal, suggested that mountains were compensated because they were floating upon a heavy subterranean magma. Pratt never went as far as this; he merely said, "the mountains are compensated"; Airy went further; he said, "the mountains are floating." Distinguished geologists, Fisher, Dutton, Oldham, have developed the idea of flotation.

The theory of flotation lays down that the mountains are supported in their present positions by hydrostatic pressure, just as an iceberg floats upon water. I have no time to discuss this theory at length, but I should like to point out to you that if an iceberg floats upon water, its weight must be compensated by underlying deficiencies of density: the theory of flotation does net state this with regard to mountains; it states the converse, *viz.*, that as mountains are compensated they must be floating. The principle of hydrostatic pressure demands that if any mass is floating it must be compensated; it does not, however, follow that if a mass is compensated it must be floating. The theory of flotation is based upon the assumption that the compensation of mountains is complete and perfect; but we have not found complete compensation in India; the outer Himālaya are compensated to the extent of 80 per cent. As iceberg would not float, unless its compensation were exactly complete; the fact that mountain compensation is nowhere quite complete or perfect is a serious argument against flotation. This imperfection of compensation differentiates rock from water: it denotes rigidity. What I have been calling the theory of flotation is frequently called the theory of Isostasy. I have however purposely avoided using the word Isostasy, as its exact meaning is open to question. Isostasy is a condition of approximate equilibrium, not perfect equilibrium like the condition of flotation. Isostasy is a condition of compensation in a solid crust; it does not necessarily imply hydrostatic support, as flotation does. I therefore hesitate to apply the word Isostasy to the flotation theory; for Isostasy can exist without flotation.*

MOUNTAINS ORIGINATE AT GREAT DEPTHS.

A very important work has been that of Mr. Hayford who has recently discussed the results of the plumb-line at a large number of stations in America. He has confirmed Pratt. Hayford has investigated the depth to which the deficiency of density underlying mountains goes down, and he has found that that depth is between 60 and 90 miles. That is to say, he has shown that the depth of subterranean compensation is very great compared with the height of mountains. The discovery that mountains originate from the great depth of 60 to 90 miles is the second important contribution of geodesy to this study; the first was compensation, the second is great depth.

* The idea of flotation has arisen because the question of mountain-support has been given precedence of the question of mountain-elevation. Questions of support and maintenance should be subsidiary to questions of formation and origin. If mountains are due to the vertical expansion of rock, a theory of flotation is superfluous.

Most books are written on the assumption that mountains are surface wrinkles and that their structure can be determined by examining surface rocks.

The Sātpurā range runs east and west south of the Narbadā; the plateaux of Hazāribāgh and Chotā Nāgpore are the eastward continuation of the Sātpurā range. A high authority has stated that the Hazāribāgh and Chotā Nāgpore plateaux can have no real connection with the Sātpurā range, because they are formed of different rocks. But if we regard this range as rising from a depth of 75 miles, its elevation will be seen to be due to a deep-seated cause that has nothing to do with the surface rocks. One deep-seated cause has lifted up this range from the Narbadā to Hazāribāgh irrespective of the kind of rocks lying on the surface.

THE GANGETIC TROUGH.

I have now discussed the two principal theories of Himālayan elevation, the Contraction theory and the Flotation theory. Let us consider for one moment how this deep Gangetic trough is explained by these two theories. For a great number of years the Contraction theory ignored this trough; it was, I think, Professor Suess who first recognised that the trough had to be fitted into the Contraction theory. His explanation of it was this: as the Earth's interior contracts, the surface of Asia is wrinkled, the wrinkles get pushed southwards against the Indian table-land, and the rock surface of Northern India gets compressed into a downward bend between the mountains and the table-land. This explanation is not satisfactory: if the surface of Asia is being pushed southwards in wrinkles against the table-land, it is difficult to understand how it is that a deep trough borders the table-land. Why should the solid crust be bent downwards by a horizontal pressure from the north? If the crust is being pushed against this table-land, it should be heaped up all round it.

The explanation of the Gangetic trough that is supplied by the Flotation theory is this: the Earth's crust is likened to a floating raft: the more weight you place upon a raft, the deeper it sinks into water. The Ganges and Jumnā and other rivers are continually depositing fresh sediment upon these plains, and the crust according to this theory continually sinks downwards by the weight of the sediment. When we see the massive rocks of Kaimur and Mirzāpur supported easily by the crust, it is difficult to believe that it cannot support a thin layer of silt without yielding.

You will see from this chart, that the Ganges and Indus have filled up their trough with silt, but that the Tigris and Euphrates are behindhand; the Persian Gulf is an unfilled trough which will be filled in time.

Here is a chart of Japan, showing the Tuscarora deep, a long submarine trough; it is over 24,000 feet deep, and it is continued to the north-east by further troughs lying in front of the Kuriles and Aleutian Islands, and attaining depths of 28,000 feet. How then can it be argued that the Ganges trough has been created by the weight of its own silt, when we see that the Euphrates trough and the Japanese trough are unfilled? These troughs exist before the silt comes to them. The idea that the weight of silt causes subsidence arose, I think, from the fact that the places where silt is being deposited are frequently found to be subsiding. But the truth may be

this: a river carries its silt to the lowest hole in the crust it can find; the lowest holes near continents are those where the crust is subsiding; rivers thus deposit their loads in places of crustal subsidence, but their loads do not cause the subsidence.

SOUTHERLY DEFLECTIONS PREVAIL OVER THE GANGES PLAINS.

Now let me tell you of the third discovery due to this plumb-line. The Survey found that at 60 miles from the hills this plumb-line hung vertically and Pratt deduced the Theory of Mountain Compensation. But when the Survey began to extend their operations, a new phenomenon came to light which caused great surprise. All over the United Provinces at distances exceeding 70 miles from the hills, this plumb-line was found to hang decisively away from the mountains; at Fyzābād, Cawnpore, Benares the plumb-line is deflected southwards: here at Lucknow it is deflected 9″ to the south. If the Himālaya were simply compensated, this plumb-line should be hanging at Lucknow exactly vertical; if the mountains were not compensated, it should be deflected here about 50″ towards the north. But it is deflected 9″ towards the south. The observers were astonished to find that at places in sight of Himālayan peaks the plumb-line turned away from the mountain mass; that at Amritsar in sight of the Dhaola Dhār snows it was deflected towards the low Punjab plains; that at Multān in sight of the Takht-i-Sulaimān mountains it was deflected towards the desert; at Bombay it was deflected seawards away from the Western Ghāts; on the east coast of India it was deflected seawards away from the Eastern Ghāts.

The new lesson to be learnt from the plumb-line is this; a hidden subterranean channel of deficient density must be skirting the mountains of India. Here in North India is a wide zone of deficient density, of crustal attenuation; it is the presence of this zone of deficiency that accounts for the southerly deflection of the plumb-line. What is the meaning of this zone? How has it come into existence?

If you look at this section (plate 2) the Earth's crust in these outer Himālaya has been compressed laterally: of this there is no doubt. The area between the snowy range and the foothills is a zone of crustal compression. And I suggest for your consideration that the Gangetic trough, this zone of deficiency, is a zone of tension in the crust. The crust has been stretched here and attenuated. Here you have compression, and alongside is the tension. The tension is the complement of the compression. I have pointed out that the Himālaya mountains are largely, but not completely, compensated by their underlying deficiencies of density: their compensation is however rendered complete by the presence of the Ganges trough; if the Himālayan compression and the Gangetic tension are considered together, it will be found that there is no extra mass.

Geodesy thus teaches that the Gangetic trough and the Himālaya Mountains are parts of one whole. The Contraction theory and the Flotation theory both treat the Gangetic trough as though it were a secondary effect of Himālayan elevation. But this Gangetic trough may have been the first and the decisive event; the Himālaya Mountains may have been a secondary effect, a sequel to the opening of the trough.

HYPOTHESIS OF A RIFT.

I showed you on the evidence of the plumb-line that the Gangetic trough was a zone of crustal attenuation, a zone in which the Earth's crust was deficient in density. I then took one step forward and suggested that it was a zone of tension. I will now take another step forward and suggest to you that there has occurred an actual opening in the sub-crust, and that the outer crust has fallen in owing to the failure of its foundations. I suggest that the Ganges plains cover a great rift in the Earth's crust.

The Earth is a cooling globe; an increase of temperature occurs as we descend into mines; and this temperature gradient is a proof that the Earth is losing heat by conduction outwards. The discovery of radium has not affected the argument.

The smaller bodies of the solar system, the Moon and other satellites seem to be cold; the Earth has a cold exterior and a hot interior; the larger planets are believed still to display heated surfaces, whilst the Sun is still a globe of fire. The inferences are warranted that ali the bodies of the solar system were hot at one time, and that the smaller have lost their heat. So I say that the Earth is a cooling body. The rock composing the crust and sub-crust is however a bad conductor, and the interior of the Earth will not shrink away from its crust, as has been assumed in the Contraction theory. The inner core of the Earth is in fact not losing heat appreciably. The outer shell was the first to lose its heat, then the shell below it, and the sub-crust is now losing its heat more quickly than the interior core. As the outer shells contract from cooling, they become too small for the core, and they crack. Supposing we had here a great globe of rock, red-hot throughout; how would it cool? Can you imagine it cooling in such a way that the core became too small for the outer shell, and the outer shell became wrinkled? No; the outer shell would cool first, and would crack.

The outer shell of the Earth was the first to crack millions of years ago: now a lower shell, the sub-crustal shell, is cracking. When a crack occurs in the sub-crust, parts of the upper crust fall in.

You will see that this Indus-Ganges trough has the appearance of a crack. And there are reasons for believing that these Himālaya have been split off from this ancient table-land and have been moved northwards and crumpled up into mountains. This Assam plateau is stated by geologists to resemble in its structure and rocks the Indian table-land; Assam has been split off and moved away.

Here are the Bengal coal-fields, and just opposite on the other side of the trough are the Sikkim coal-fields; and the coal in the two places is similar. The rocks of the outer Himālaya have been very much crushed, but they still bear a resemblance to the rocks of the Vindhyan table-land.

Here are the Arāvalli mountains which end now at the Delhi ridge; Mr. Middlemiss has found signs of a transverse strike in the Himālaya on a continuation of the Arāvalli alignment.

Similarity also exists between the rocks in Cutch and those on the other side of the Indus in the hills of Sind.

FROM THE BAY OF BENGAL TO THE MEDITERRANEAN.

Geologists have discovered that the ancient table-land of the Vindhyas and Deccan is a remnant of a much greater table-land that in very early

ages included Africa and Arabia. Africa and Arabia and the Deccan table-land are in fact fragments of one extensive and ancient continent. Hitherto I have been considering the peculiar trough that skirts the northern edge of the Indian table-land. Let us now consider whether this trough is continued to the east or to the west.

On the east we find one of the great linear deeps off the coast of Java and Sumatra. It is 24,000 feet deep. In 1883 the Krakatoa eruption took place in the Sunda Straits. Great depths have also been discovered off the Nicobar Islands and earthquakes have occurred on the Chittagong coast. In continuation of the Gangetic trough we thus find in the Bay of Bengal a line of seismic activity, and of submarine deeps.

To the west of Karāchi we see the Persian Gulf, and the plains of the Tigris-Euphrates. The plains of the Tigris-Euphrates are very similar to those of the Ganges: they consist of mud, sand and sediment lying in a long trough between the ancient table-land of Arabia and the mountains of Persia.

Further west we find the Euphrates trough is continued by the Mediterranean Sea, and the Mediterranean is bounded on the north by the Taurus mountains, by the Balkans, Carpathians, Appenines and Alps.

Throughout the whole distance from Calcutta to Sicily we see that the old table-land India-Arabia-Africa is bounded on the north by a long trough, and that this trough is in its turn bounded by the younger mountain ranges from the Himālaya to the Alps. Geologists have discovered that all these mountain ranges were elevated in the same era; they are all of the same age.

I submit for your consideration that the Ganges-Indus-Euphrates-Mediterranean trough is an indication at the Earth's surface of a rift in the sub-crust.

When we get as far west as Sicily, we reach a region of active volcanoes, Etna and Stromboli. Italian geologists believe that Sicily has been separated from Africa by recent subsidences.

THE EARTHQUAKE RECORD.

The whole zone from Java to Sicily has been visited by earthquakes throughout the historic period. And the recent earthquakes in Shillong, Dharmsāla and Messina show that seismic activity is continuing in our time. This is in fact one of the zones of the Earth, along which earthquakes occur most frequently.

In the last 300 years 64 destructive earthquakes are known to have occurred in India:* there may have been others of which there is now no record. Of the 64 violent Indian earthquakes 58 have occurred along the Indus-Ganges zone. These may be grouped as follows:—

Assam-Bengal	20
Outer-Himālaya	11
Northern Punjab and Kashmīr	17
Southern margin of Gangetic plain	4
Cutch and Sind	6
Total	58

* Milne's Catalogue of Destructive Earthquakes.

If we consider the whole zone from Bengal to Sicily, we find from Milne's catalogue that the numbers of destructive earthquakes since 1615 can be grouped as follows:—

India	58
Mesopotamia and Syria	28
Eastern Mediterranean	116
Italy	482

In the last 300 years a destructive earthquake has occurred in Northern India on an average once in every 5 or 6 years.

FROM LOB NOR TO THE BLACK SEA.

Let us now glance to the north of the long mountain zone that extends from China to France. You will see north of Tibet there is the large inland basin of Lob Nor; then here are the low-lying plains of the Oxus; then come the Caspian and Black Seas. Now all four of these depressions are believed to be subsidences of the Earth's crust. South of the line of mountains we see a long continuous trough: north of the line of mountains we find not a continuous trough, but a series of separate depressions. Now these depressions are separated from one another by fragments of mountain ranges which once ran parallel to the Himālayan-Alpine trends. Here you see the Pāmirs. The high Pāmir plateau consists of parallel ranges running east and west. The eastern and western continuations of the Pāmir ranges seem to have foundered into the abyss, those on the east have fallen into Lob Nor, those on the west into the Oxus depression.

Here again you will see that one of the chains of the Caucasus has foundered into the Caspian, and the western extensions of the Caucasus have fallen into the Black Sea.

Why are these mountain ranges collapsing? May it not be that the Earth's crust is cracking and these mountains are falling into the rifts?

THE BOMBAY COAST.

I must now invite your attention to the Bombay Coast. From the Tāpti to Cape Comorin runs the range of mountains known as the Western Ghāts. This range is parallel to the coast of India and about 40 miles inland; it rises suddenly with a steep scarp. The strata are almost as horizontal as when first laid down; they have never been compressed or folded.

The Survey has observed the plumb-line at different points along this coast; it is always deflected strongly towards the sea. To the west of Bombay and Mangalore there is the deep sea; and to the east there is a massive range over 4,000 feet high; yet the plumb-line will hang seawards. If the Western Ghāts possessed the mass which they appear to possess and which the Suess school ascribes to them, then the Bombay plumb-line should be deflected 15 seconds towards them. If on the other hand the Western Ghāts are compensated by deficiencies of mass underlying them in accordance with the compensation theories of Pratt and Hayford, then the plumb-line should hang vertically at Bombay. But the plumb-line takes neither of these courses; it hangs towards the sea. We have been puzzled for years by the plumb-line at Bombay;

we used to think that the rock under the ocean must be so dense and heavy, that it was able to pull the plumb-lines towards the sea. Major Cowie, however, observed in the south of Kāthiāwār, and found that the plumb-line here had a strong landward deflection. The seaward deflections occur throughout the Bombay coast but not round Kāthiāwār. It is only quite recently that we have realised we have here at Bombay the same phenomenon as at Lucknow.

In Northern India the plumb-line will persist in hanging away from the visible mountains and at Bombay it takes the same course, and when I consider its constant seaward deflection, I can only suggest to you that there must be, between Bombay and the Western Ghāts, a zone of subterranean deficiency, a zone of fracture and subsidence like that of the Gangetic plains.

The secret is hidden below the Earth's crust: you will see that the Ghāts have been forced (possibly by underground fracture), into a decided curve just above Bombay harbour; it is significant that at this curve the Deccan Trap rises to its highest point, Kalsūbai.

I suggest to you that a crack in the sub-crust has extended from Cape Comorin to Cambay, and that as this crack has occurred the Western Ghāts have been elevated. The crack has been filled by masses of fallen rock and by alluvial deposits brought down by rivers.

Geologists have shown that this range consists, from latitude 20° to 16°, of the lavas of the Deccan, comparatively recent rocks, whilst from latitude 16° to 8° the range consists of ancient metamorphic rocks. The rocks of the northern part of the range are of different age and structure and origin from the southern.

Nevertheless geodesists contend that this is one and the same range: the rocks composing it have had nothing to do with its elevation. The Western Ghāts have been elevated, after the Deccan lavas had become solidified into surface rocks. Their elevation has taken place in the Tertiary age.

Now I will turn to the Eastern Ghāts; at Madras and at Vizagapatam we find the plumb-line hanging towards the sea. Here we have the same phenomenon, as we witnessed at Lucknow and at Bombay, the plumb-line turns away from the mountains. I will not repeat myself, but I suggest again that this coastal zone like the western covers a sub-crustal crack.

I told you just now that in the last 300 years there had been 64 destructive earthquakes in India: of these 58 had occurred along the Indus-Ganges trough. Where did the remaining six take place? Three of them occurred on the Bombay-Surat coast; the other three on the Madras coast. No destructive earthquakes are recorded as having occurred at Hyderābād, or at Bangalore or at Nāgpore.

The ancient table-land of India is in the shape of a triangle, but its two wings, Assam and Cutch, have been severed from the main body: this may have been due to the coast-line cracks.

Assam-Bengal has had 20 destructive earthquakes in the last 300 years, and though only 6 have been recorded in Cutch and Sind, yet this western fragment of the table-land is a seismic region. In 1819 Bhūj was destroyed and every town in Cutch was injured; numerous fissures were seen throughout the land. North of Sindhī a drop 16 feet deep and 50 miles long, shown here on plate 4, suddenly appeared on the plains which had hitherto been as level as the sea. On account of its sudden appearance across the old bed of

the Indus it was named by the inhabitants the Allah Bund, and by this name it is now known in geography. It was due to the subsidence of a large area to the south.

Many of the destructive earthquakes of Sind have not been recorded in history, but the ruins of strong buildings with human bones buried below them are evidence of sudden destruction by earthquake.

THE DEPTH OF THE GANGETIC RIFT.

I have been describing zones of deficiency and have suggested that they are cracks in the sub-crust. I have now the task of discussing the possible depths of these cracks.

By the depth of the Gangetic rift I do not mean merely the depth of the loose sediment; I do not mean the depth at which solid rock is first met with. If a rift has extended to a considerable depth, it may in its lower portion have become filled by solid rock that has fallen in from the sides, or by volcanic eruptions. Even if the Ganges sediment continues down to a depth of some miles, it may itself become consolidated by pressure and heat.

I define the depth of the rift as follows: it is that depth at which the rocks under the Ganges plains are similar to rocks at the same depth under the table-land (plate 2). There may be a solid floor to the Gangetic trough at a depth of 6 miles under Gorakhpur, but if the rocks which are deeper than 6 miles under Gorakhpur are different from and lighter than the rocks of the same depth under the Vindhyan plateau, the solid floor is not the bottom of the rift. When a crack occurs, volcanic eruptions are to be expected, and although there are no volcanic cones rising now from the trough of the Ganges, there probably were at one time. Dr. Pilgrim has discovered that there was great volcanic activity in the Persian Gulf at one time and that the islands now existing in the Gulf are isolated volcanic peaks. There exists also an old volcanic region in the Syrian desert between Baghdad and Damascus.

In considering the depth of the Gangetic rift we must appeal firstly to geodesy, and then to seismology. Now geodesy tells us that the compensation of the Himālaya (*i.e.*, the root of the Himālaya) extends downwards to a great depth: Mr. Hayford estimates 75 miles. We do not contend, and Mr. Hayford does not contend that this value of depth is proved. The depth may be 60 miles: it is I think of that order. Geodesy says that the depth is great. I regard the Gangetic plains and the Himālayan range to be the two parts of one whole; I believe that they have originated together, and if the depth of Himālayan compensation extends down to 60 miles, then I think that the Gangetic rift may extend down to that depth also.

Now let us turn to seismology: seismologists are able to form rough estimates of the depths of earthquakes. The earthquakes that visit Northern India seem generally to be most violent at places in the outer hills, such as Dharmsāla, Kātmāndu, Shillong. But the line of fracture that occurs in the sub-crust at an earthquake may not be vertically under the place which suffers most. If, for example, a fracture in the sub-crust occurred at 60 miles depth under Gorakhpur, the hills to the north might be raised, and this elevation, though a secondary effect, might do more damage at Kātmāndu than the earthquake itself could do at Gorakhpur, which is protected by some miles of soft blanket of sediment underneath it. In the Dharmsāla earthquake Middlemiss

estimated its depth to be between 12 and 40 miles. Middlemiss's maximum value is not very different from the geodetic value.

It is an interesting question to consider whether a fissure in rocks could extend downwards to a great depth. From a place near the Indus in Kashmīr it is possible to see a continuous wall of rock 4 miles in height, in the flank of Nanga Parbat. Mount Everest stands erect 5½ miles above sea-level; its summit stands firm and rigid 11 miles above the depths of the Bay of Bengal. We have therefore evidence that the materials of the crust are strong enough to admit of the continued existence of great differences in altitude.

But Mount Everest is standing in air, whereas a crack in the sub-crust becomes filled with rocks falling in and with fluid rock magma from below; and the walls of the crack thus get a support that Mount Everest does not possess. It seems to me quite possible that a crack such as I have described may have extended down to a depth of 60 miles by successive fractures at increasing depths, the opening being filled by falling material.

INTERNAL CAUSES OF MOUNTAIN ELEVATION.

I have shown you how zones of subsidence in the crust are bordered by mountains, and I have now to discuss the relationship of subsidence to elevation, of troughs to mountains. The Red Sea is a zone of fracture, and it is bordered on each side by a zone of elevation. But along the Bombay coast the zone of subsidence is bordered only on the one side by a zone of elevation. The sub-crustal crack from Surat to Cape Comorin has been accompanied by a vertical uplift of the Ghāts, and I suggest for your consideration that the vertical force which elevated the Ghāts was the expansion of the underlying tock due to physical or chemical change.

Mr. Hayden informs me that the specific gravity of the rock composing the Nīlgiris varies from 2·67 to 3·03, that is 14 per cent., and that the rock of the Hazāribāgh plateau varies from 2·5 to 3·1, 24 per cent.

The Western Ghāts appear to have risen about 4,000 feet. Now we know that the Western Ghāts are largely compensated by underlying deficiency of density; if the compensation of the Western Ghāts extends downwards to a depth of 60 miles, then an expansion of two per cent. would be more than sufficient to account for the elevation of the Ghāts. Mr. Hayden finds variations of 14 and of 24 per cent. in the densities of surface rocks, and yet an expansion of only two per cent. would account for both the elevation and the compensation of the Ghāts. Geodetic observations show that the compensation is not perfect, and that the Ghāts contain an amount of rock in slight excess of the normal crust: the vertical expansion of rock must thus have been accompanied by a slight horizontal compression insufficient to fold the surface strata, but sufficient to account for the imperfection of the compensation.

The heterogeneous rocks composing the Earth's crust are continually undergoing changes of structure, known to geologists as metamorphism. At a depth of 30 miles the temperature is sufficiently high to melt all known rocks; but increase of pressure raises the melting point, and the increase of pressure underground may be sufficiently great to counteract the effects of the increase of temperature. So that at a depth of even 60 miles rocks may still be solid and rigid, as geodesy leads us to believe they are.

We have to imagine how deep-seated rocks, that have been buried for millions of years under high temperatures and enormous pressures, how they would behave, if a crack penetrating downwards from the Earth's surface reached and disturbed them. I suggest for your consideration that two cracks opening, one on the West Coast and one on the East Coast of India, have compressed the Indian Peninsula between them. This lateral pressure was insufficient to crumple the table-land; but may it not have been the exciting cause that led deep and ancient rocks to expand vertically and elevate the Deccan? Petrologists will be better able to discuss this question than I am.

The main ranges of the Himālaya are composed of granite; this granite has protruded upwards from below. I suggest that the protrusion of granite is due to expansion of rocks in the sub-crust. The great Himālayan range is 5 miles high; and the compensation of this range, that is, its underlying deficiency of density, is estimated to extend downwards to a depth of perhaps 75 miles. An underground expansion of 7 per cent. would be sufficient to account for the elevation of the Himālaya.*

Many of the faults which intersect the Himālaya may, I think, be ascribed to the shearing, which must have ensued when certain areas of the crust were forced vertically upwards by the metamorphism of sub-crustal rock. Many distortions of surface strata may be ascribed to local variations in the vertical expansion of deep-seated rocks.

EXTERNAL CAUSES OF MOUNTAIN ELEVATION.

The Western Ghāts are as mountains very small compared to the great ranges that stretch from China to France; the former are an example of vertical elevation without any obvious horizontal compression of the surface; the latter exhibit both vertical elevation and considerable compression by lateral thrust. In the Western Ghāts expansion of the subterranean rock seems to have uplifted the surface strata without disturbing the latter; in the Himālaya the subterranean rock has expanded to such an extent that it has burst through the surface rocks in the form of granite, and in its protrusions it has pushed aside the surface strata and helped to crumple the latter. The troughs skirting the Western and Eastern Ghāts may have been caused by the mere cracking of the sub-crust from cooling. But the Indus-Ganges trough is so large, and the mountains to the north of it constitute so unique a protuberance that the idea arises that some external force must have pulled the Himālaya northwards from India, and must have torn into a great rent the original line of tension that had opened under the Ganges plains.

The Earth possesses a figure of equilibrium. If the Earth was at rest, its figure would be that of a perfect sphere; as it is rotating, the velocity of rotation has caused much extra rock to be heaped up round the equator: the diameter at the equator is 27 miles longer than the polar diameter.

Sir G. Darwin thought that the Earth's velocity of rotation was constantly being decreased by the Moon's attraction upon our oceans; he thought that

* If underlying deficiency of mass is greater than the excess of mass in a mountain, the plumb-line will be deflected away from the mountain. Over-compensation would therefore account for deflections *away* from mountains. But it would not account for tension or subsidence in the fore-deep. Pendulum observations in the outer Himālaya and at Ootacamund indicate not over-compensation but imperfect compensation.

the tides were tending to stop our rotation, just as the Earth's attraction has entirely stopped the Moon's rotation. If our rotation velocity is decreased, the figure of the Earth changes and becomes nearer and nearer to a sphere: water can flow from the equator to the poles at once, and the oceans can immediately assume the new form of surface suitable to the decreased rotation velocity. But a superfluity of rock would remain at the equator, and the straining of this towards the poles might cause cracks in the Earth's surface. I do not presume to say that this is the cause of the rent in the Earth's crust hidden below the Ganges plains. All I wish to point out is that these mountains appear, as if they had been pulled northwards out of the Ganges-Euphrates-Mediterranean rent, and I show you some reasons for believing that the Earth's figure may have undergone deformations. The astronomical cause of these deformations is hidden in the past history of the Earth. In the Permian era an ice age occurred in equatorial regions; if the Earth's rotation velocity were to decrease considerably now, Southern India and equatorial Africa would stand out as rock protuberances high above the ocean, and would exhibit snow and glaciers.

Every year the Earth is bombarded by swarms of small meteors; is it not possible that at certain times in the distant past the Earth received larger meteoric masses than in the historic period, sufficiently large perhaps to upset the Earth's equilibrium by displacing its centre of gravity? Its figure would then be forced to undergo readjustments. If the Earth meets a swarm of meteors in space, and if some of them approach within its attraction, it seems possible that almost all the captured meteors may fall upon that hemisphere of the Earth which first meets the swarm, whilst the other hemisphere may receive very few. This would interfere with the Earth's balance.

Whilst something may occur in one age to cause movements of rock towards the pole, another cause may arise at a later date that will tend to oppose those movements. Not very long ago a great ice age occurred, and all Northern Europe and America were buried under ice: an immense volume of sea-water must then have been transferred from the equatorial oceans to the north pole: this may have disturbed the Earth's equilibrium and have displaced its centre of gravity.

In the same ice age the Himālaya and Tibet became capped with greater masses of snow and ice than they now carry. The glaciers that now end at 12,000 or 13,000 feet descended in the Ice Age to 5,000 feet. This increase in the weight of the Himālaya was an additional deformation of the Earth's figure of equilibrium.

I suggest to you that the great mountains from China to France have been due, firstly, to a line of fracture from Bengal to Sicily, and, secondly, to adjustments of the Earth's figure.

The Andes trend north and south; they are of the same age as the Himālaya. If the Earth's figure is undergoing deformation, and a rent is torn in the crust along an east to west line under the influence of forces seeking to restore equilibrium, it seems possible that secondary cracks might occur and that the Andes may be the result of one of them. The Andes are shown to scale on this chart: you will see that in length they are not very much less than the China to France ranges, but in breadth and mass they are relatively insignificant.

You will notice from this chart (8) the peculiar curve of the northern Tibetan border, concave on the east, convex on the west. This sinuous curve

is reproduced in the north of Persia, and again in the Carpathians. The Persian ranges all have a trend from south-east to north-west except that the Caspian subsidence seems to have pushed rudely in from the north and forced the northern range into a sinuous curve. It is significant that at the point of the Caspian push stands the peak of Demavend, the highest point in all Persia. *Elevation is the companion of subsidence.** Similarly the Lob Nor subsidence appears to have squeezed Western Tibet into what resembles the neck of a bottle, and on the edge of this subsidence stand the highest peaks of the whole Pāmir region. Just as the Deccan table-land was squeezed between the western and eastern coastal cracks, so has the Tibet table-land been squeezed between the cracks of Lob Nor and the Ganges.

The conclusions which I have ventured to submit to this meeting may be summarised as follows:—

(1) The fundamental cause of both elevation and subsidence is the occurrence of a crack in the sub-crust.

(2) Mountains are compensated by underlying deficiencies of matter.

(3) Mountains have risen out of the crust from a great depth, possibly 60 miles.

(4) Mountains owe their elevation mainly to the vertical expansion of subjacent rock.

I have now had the great privilege of placing certain problems before you. My endeavour has been to point out to this Congress, and especially to its younger members, the many scientific secrets that are lying hidden under the plains of Northern India.

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* See "Sketch of the Geography and Geology of the Himālaya Mountains and Tibet," page 160. See also "Records of the Survey of India, Vol. IV," page 3, "Note on the discovery of the peak of Namcha Barwa."

TURCO-PERSIAN FRONTIER COMMISSION.

REPORT BY LIEUTENANT-COLONEL C. H. D. RYDER, C.I.E., D.S.O., R.E.

Many attempts have, in the past, been made to settle the frontier between Turkey and Persia; extending as it does from the Persian Gulf to Mount Ararat, through very inaccessible country peopled by Arabs and Kurds who owe only a nominal allegiance to either side, it is not to be wondered at that this problem should have defied a solution for so long a time.

The first serious effort, started in the year 1849, came to an abrupt conclusion owing to the Crimean War, and even after that war it was many years before the results of the Commission were published in the shape of a map of a strip of country about 30 or 40 miles wide, somewhere within whose limits the mediating, *i.e.*, British and Russian Commissioners, declared the frontier lay. This map in 10 large sheets on the scale of 1 inch=1 geographical mile known as the Identic Map formed henceforth the basis of future discussions, and was in fact accepted as such for the purposes of this Commission.

A further effort to settle the frontier was stifled by the Russo-Turkish War of 1878, after which the subject hardly got beyond the discussion stage until after many delays the protocol of 14th November 1913 was signed by the four Governments concerned and an International Commission was formed to make one more attempt to settle the frontier.

This protocol was of value in that it placed a great part of the frontier beyond the regions of discussion, and, in cases where the Turkish and Persian Commissioners might disagree, contained the invaluable proviso that they should within 48 hours place their points of view and arguments before the Mediating Commissioners who would then and there decide the question. I strongly commend this point to those who have to settle frontiers in the future; the parties chiefly concerned often disagreeing on principle and only wanting a third party to decide the question for them.

The four Commissioners were to meet at Muhammareh in December 1913, and to accompany the British Commission a detachment was formed from the Survey of India, consisting of Lieutenant-Colonel C. H. D. Ryder, C.I.E., D.S.O., R.E., Major H. McC. Cowie, R.E., Mr. Haji Abdul Rahim, K.B., Extra Assistant Superintendent, Mr. Sher Jang, K.B., Sub-Assistant Superintendent, Surveyors Hamid Gul and Sijawal Khan and 42 *khalāsis*. Leaving Karāchi on 6th December the bulk of the party reached Muhammareh on 12th December 1913, Major Cowie remaining at Būshire for a week for longitude observations.

The British Commissioner, Mr. A. C. Wratislaw, C.B., C.M.G., and the Secretary to the Commission, Mr. G. E. Hubbard, who had both come out from England, arrived by the same steamer. Captain A. T. Wilson, Deputy Commissioner, was already at Muhammareh making preliminary arrangements, while Captain A. H. Brooke, 18th K. G. O. Lancers, commanding the escort of 30 men of his regiment, and Captain H. W. Pierpoint, I.M.S., Medical Officer, joined a fortnight later. Captain F. L. Dyer, 93rd Burma Infantry, who was then studying Persian at Muhammareh, was afterwards attached as transport officer.

We found a good camp pitched by Captain Wilson in readiness in the desert just outside the palm groves, the Russian Commission being located in a house in the town.


TIFLIS
Baku
CASPIAN SEA
Mt. Ararat
Bayazid
Maku
Khoi
Kotour
Van
Dilman
TABRIZ
LAKE URUMIEH
Urumieh
Ushnu
Sardasht
Baneh
Lesser Zab R.
Sulaimanieh
Auroman Range
PERSIA
Diala R. or Sirwan R.
Zuhab
Qasr Shirin
Kirmanshah
Khanikin
Mandali
BAGHDAD
Tigris R.
Tib R.
Dawairij R.
Dizful
Karkha R.
Ahwaz
Kushk-i-Basri
Karun R.
Euphrates R.
Shatt-el-Arab
Basrah
Muhammareh
Fao
PERSIAN GULF
Kuwait
Bushire
TCH MAP
RATE REPORT ON
FRONTIER COMMISSION
C.H.D.RYDER. C.I.E. D.S.O. R.E.
or 1 Inch = 96 Miles
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50
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The personnel of the other Commissions was as follows:—

Russian Commission.

M. V. Minorsky, *Commissioner.*

M. D. Bilaiew, *Deputy Commissioner.*

Captains Tshahakaya and Aliew, Survey staff, strengthened at a later stage by Lieutenant-Colonel Krimlikoff, and Captains Yordanoff, Yemilianoff, and Chernoff, also Lieutenant-Colonel Andriewsky in charge of the survey and escort.

They were accompanied by a medical officer, Dr. Volodyeusky, and various officers in command of the Cossack escort.

Turkish Commission.

Major Aziz Samih Bey, *Commissioner.*

Captain Abdul Hamid Bey, *Deputy Commissioner.*

Basri Bey, *Secretary.*

Captain Mehmet Effendi (replaced later by Captain Salih Effendi) and Lieutenant Kadri Effendi, Survey Officers.

A medical officer and escorts of varying strength.

Persian Commission.

Etela-ol-Mulk, *Commissioner.*

Mansur-es-Sultaneh, *Deputy Commissioner.*

Salar Muzaffar, *Military Adviser.*

Abdur Rezagh Khan, Survey Officer, and two topographers.

A medical officer and escort of Persian Cossacks.

Pending the arrival of the Turkish and Persian Commissions, we obtained the longitude of Fāo, at the mouth of the Shatt-al-'Arab by telegraphic connection with Būshire, a station of the longitude operations of 1895 connecting India with England. All attempts to carry up a series of small triangles from Fāo to Muhammareh on the banks of the river were frustrated by the upsetting of a boat and loss of a good deal of the *khalāsis'* kit, and a naval triangulation was accepted in its place. Nasiri (Ahwāz) was also connected with Muhammareh by telegraphic longitude observations, the former place being the starting point for Major Cowie's triangulation. The Persian Commissioner had arrived with the Russians by sea in a Russian steamer, but the rest of his staff came overland from Tehrān, *via* Baghdad, and being delayed by a visit to Kerbela did not arrive till the middle of January 1914 about the same time as the Turkish Commission. Further valuable time was spent in the necessary formal exchange of calls, and serious business only commenced with the first full meeting of the Commissions on 21st January in a fine house belonging to the Chief Minister to the Shaikh of Muhammareh.

The Commissioners were desirous that the Identic Map, already referred to, should be used as much as possible and for the first portion of the frontier, the Shatt-al-'Arab itself, this was possible, the Persian bank of the river forming here the frontier, but as we progressed the reputation of this map became less and less sacred, as glaring errors were discovered, till finally it was abandoned and new maps of the frontier and its neighbourhood were prepared.

A more or less formal trip down the river to Fāo, and up river to the point where the frontier leaves the river, constituted our first work of the demarcation, the first pillar being built at this latter point, consecrated by the

slaughter of a sheep, speeches of mutual congratulation, and a large lunch in Arab style provided by the local Shaikh. Geniality and good fellowship pervaded the air and continued with but few interruptions throughout the duration of the Commission; I doubt very much whether any Frontier Commission has been carried through with so little friction, taking into account the long standing feud which had existed between Turks and Persians over the frontier.

The boundary after leaving the Shatt-al-'Arab disappeared into the desert, and all that was necessary was to build a few pillars to give its direction and then visit Kushk-i-Basri in the desert to pick up the line again. This place, over 30 miles from Muhammareh, was somewhat difficult of access owing to the lack of water, however by going up the Kārūn river for a day by steamer we got within 20 miles and then marched across the desert. We here had our first experience of desert work; the long weary march ever in sight of camp but never getting there, the heat in the daytime with its attendant mirage, the cold at night, and on our return journey heavy rain which turned the hard dry desert into a slippery marsh, making any progress at all a difficult matter, all formed an interesting first experience, but one which we had repeated too often during the next three months to appreciate its real delights. Truly Mesopotamia is a difficult country to survey in; the cold weather is the rainy season, and during the hot weather, after the end of March, any observations even of the roughest nature are next door to impossible owing to the mirage.

On this trip we noticed a curious feature in the otherwise monotonous desert in a large number of parallel lines having the appearance of canals filled in containing evidently something different in their soil, as small bushes grew more frequently there than in the rest of the desert; their width was from two to four yards and in places they converged with all the appearance of disused railway sidings; many theories were advanced but these lines remained a mystery to us.

Having put up our pillars near Kushk-i-Basri and turned the frontier line into the marshes we returned to Muhammareh to make preparations for our further advance.

On 14th February we made our final start, each Commission marching separately. Three long marches up the right bank of the Kārūn river and an equally long one across the desert brought us to Kut Saiyid Ali on the Karkheh river which we crossed the same afternoon, and called a very necessary halt for a day, prolonged for another day on account of a storm of wind and rain which brought down several of our tents and rendered marching impossible owing to the mud.

The Karkheh is a fine river 100 yards wide with a fast flow of fresh water which used to irrigate a large tract of country; a sudden change of its bed left the irrigated country high and dry and the greater part of its waters now flows into the huge marsh extending to the banks of the Tigris and is lost therein. No very extensive works could however easily render the tongue of land between the Kārūn river and the Tigris once more fertile and able to support a large population. The Arabs in these parts inhabit the banks of rivers and marsh during the summer, their reed huts extending for several miles along the banks turn the river at a village like Bisaitin into one long street. Our next two marches were done by boat, landing occasionally for partridge and snipe shooting, while our caravan followed the land route. At Bisaitin on

21st February we caught up Major Cowie and the surveyors who had been working ahead and marched all together to Umm Chir (the mother of pitch), a desolate spot which had been agreed upon as the next meeting place of the Commissioners, and at which the frontier line issued from the marsh into which we had consigned it west of Kushk-i-Basri.

A week's halt here made us all the more anxious to get on, as our start had been very late in the season, and the weather was already beginning to warm up. From here to the Dawairij river, a distance of 26 miles, the Identic map proved very unreliable and the old bed of the Shatt-al-Ammah which had been laid down as the frontier was in many places hardly visible having been filled up by moving sand dunes.

Another week's halt at the Dawairij river was necessitated by the river coming down in a heavy flood. The British Commission camped in the bed of the river, but fortunately crossed next morning through the rising water, though we had to move our camp twice before we were safe from the ravages of the flood. For several days the river amused itself by cutting away its bank, large masses of which fell constantly into the river with noises like the booming of heavy guns. The other Commissions were unable to cross the river for several days and then did so with difficulty having also to move their camps further and further away from the original banks; once in safety oneself it was a source of amusement watching another Commission hastily striking its tents and retiring before the rising flood.

Once across, however, the work progressed with some rapidity as our surveyors had not been wasting their time. The Identic Map had fallen into marked disfavour and we had our surveyors on ahead mapping the country preparatory to the arrival of the Commissions. All these maps were based on the triangulation carried through with unflagging energy and great accuracy by Major Cowie, the necessity of keeping up the computations *pari passu* with the observations to have this framework constantly ready for work of the surveyors, necessitated his working far into the night and was the subject of much admiration on the part of our colleagues in the other Commissions. We had now reached the foot of a low range of foot-hills thrown out to the south of the Pusht-i-Kūh range, the hills remaining in Persia while the plains inhabitated by Arabs were left to Turkey. The foot of this range was followed for three days, till we arrived at the Tyb river on 11th March. A week's halt here, although necessary, was rendered very unpleasant by the disgusting nature of the only water we had to drink; concentrated Epsom salts was our verdict on its quality.

The increasing heat and lack of potable water rendered the work of surveying and demarcation very arduous. After leaving the Tyb river we had to march away from the foot of the hills into the plain, camping a night at Qara Tapah, a small mound from which we could see passing boats and a steamer on the Tigris, floating in the air owing to the mirage, on its way to Baghdad. We reached Bāgh-i-Shāhi (Baksai) on 19th March and again put in a prolonged halt according to our usual and indeed unavoidable custom. At these halts several meetings of the Commissioners would be held at which the immediate frontier would be settled in detail while often a good stretch of frontier ahead of us was also fixed in general terms, and Sub-Commissions consisting of a representative of each nation were sent out to put up the

necessary pillars while time was thus given for our surveyors to get on with their work well ahead of the main body.

Baksai and the lands of Saiyed Hassan 30 miles distant had long been in dispute between the Turks and the Vālī of Pusht-i-Kūh on the Persian side, and finally a compromise had to be effected, disliked by both parties and therefore probably fair. Our departure from Baksai was followed by a severe intertribal fight amongst the Turkish Arabs, many being killed and wounded on both sides, the fight taking place in the presence of some Russian and Persian officers who had remained behind but were not interfered with.

We arrived at Zurbatīyah, a small Turkish town, on 6th and thence marched to Mandalī where we arrived on 10th April, without incident except for a march through a dust storm the day we left Zurbatīyah. Mr. Wratislaw left us here for a short stay in Baghdad on account of his health, rejoining us a month later at Qasr-i-Shīrīn.

Mandalī is a prosperous little Turkish town surrounded by palm groves and fruit orchards, depending for their water and life on a stream issuing from Persian territory. The rights in this water had long been in dispute, the Vālī of Pusht-i-Kūh often threatening to divert it and thus bringing pressure to bear on the Turks to admit his claims in other directions. As usual a compromise was effected and we entered on 17th April an unpleasant region of low hills from which the nomads had already cleared out on account of the heat. Oil wells were here in dispute and had to be arbitrated on; grazing was scarce and water bad, but we were relieved by a storm of wind one night, which levelled all our tents, followed by a very welcome downpour of rain which cooled the air and gave us some much appreciated drinking water.

On 25th April assisted by this short bout of cooler weather we arrived at Qasr-i-Shīrīn where a general halt had been decreed to give every one a well earned rest, the neighbourhood of Baghdad enabling the Turks especially to enjoy a return to civilisation. Our time, however, was not wasted; fair maps were prepared as far as Mandalī and despatched for publication, descriptions of the frontier were compiled and a general refit of kit, etc., was found very necessary.

Mr. Haji Abdul Rahim, K.B., with some *khalāsis* and ten of the escort returned from here to India *via* Baghdad. The ruins in the neighbourhood of Qasr-i-Shīrīn would well repay a more careful examination than we were able to make.

Leaving Qasr-i-Shīrīn on 11th May and marching *via* the Zūhāb plain we reached Bawisi, a small village at the foot of the Bamu mountain, the following day, and from there entered hilly country, and crossing the Shīrwān river on the 22nd arrived at Balkeh on the 25th May. Rain that day and the fact of our having reached an elevation of 4,700 feet brought the temperature down 20° and rendered the prolonged halt at this place and Biare one of the pleasantest we had. The Avromān range on which snow still lingered towered above us, while the narrow valleys were filled with walnut, mulberry and other fruit trees through which flowed sparkling brooks of cold water fresh from the many springs for which this range is famous. Our halt here was due partly to the intricate nature of the frontier which cut across those fertile valleys, and partly to the local Turkish officers not having received orders for the evacuation of a post they occupied within Persian territory.

These matters having been satisfactorily adjusted we marched once more on 11th June and dipping down to a plain at a height of 1,900 feet (maximum temperature 106°) crossed the Avromān range by a low pass, Chakan, and camped at Piran, a pretty spot and a pleasant climate. Our stay here was however a disastrous one, as the Persian Doctor, Hussain, met with an accident while out shooting, and had to have his right hand amputated. This he bore with great pluck and won our admiration by his cheerfulness under depressing conditions; he accompanied us, in charge of Captain Pierpoint, as far as Vazneh.

Major Cowie triangulating and our surveyors doing the detail survey had worked so well ahead that in the next week we were able to demarcate a long strip of the frontier, arriving on 23rd June at the village of Tchampar-av where the frontier left the watershed to include this village in Persia.

From here onwards we were well amongst the Kurdish uplands and only went below an elevation of 4,000 feet to cross the Lesser Zāb river on 2nd July.

It had been a great strain on every one, owing to our late start, in having thus to push on with the work during the heat of the summer, but we could now see ahead of us a probability of completing the demarcation of the frontier before winter set in, very much earlier in fact than had ever been thought of in previous estimates of the time required.

We were now in the neighbourhood of latitude 36° and the Russians after some delays took over the main topographic work. The fine upland plain of Vazneh was reached on 17th July, height 5,300 feet, and even there the maximum temperature was always in the neighbourhood of 90°.

Here, to our great regret, Mr. Wratislaw was obliged to leave for England on sick leave, Captain Wilson succeeding him as Commissioner, and Lieutenant-Colonel Ryder becoming Deputy Commissioner in addition to his own duties.

We left Vazneh on 24th July, and the following day entered the treeless tract which continues right up to Mount Ararat, and renders the scenery decidedly monotonous. From here onwards the frontier followed with a few exceptions a well marked watershed, forming a natural boundary. It never has been and never will however be a true international frontier as the Kurds from either side come up into the hills for the summer and by mutual arrangement amongst each other, Turkish tribes graze their flocks on the Persian side and *vice versâ*. This watershed was easy of demarcation as it was only necessary to place pillars on the main passes, a work carried out by small Sub-Commissions while the main body of the Commission for convenience of transport could keep to the main roads further away from the frontier, and thus reached the small Persian town of Ushnū on 28th July. Our halt of four days was enlivened by the genial hospitality of a detachment of Russian troops stationed there.

Leaving Ushnū on 2nd August we turned again towards the frontier reaching Margawar next day and that afternoon received news of the outbreak of war, although it was not till three days later that we heard of our being involved therein. The work of demarcation however continued, but a move was made into Urūmieh on 8th August to be nearer a telegraph office and to give every one another well earned rest. Here we were again the recipients of warm-hearted hospitality from the Russian garrison.

The political horizon being now cloudy, the halt at Urūmieh was cut short and the Commission leaving on 15th August moved out again in two marches

to the frontier where the boundary had to be demarcated across two valleys situated a march apart. Each of these necessitated halts of a few days, after which the main body of the British Commission under Lieutenant-Colonel Ryder marched for Kotour, while Captain Wilson accompanied the other Commissions demarcating along the watershed. Passing through the valley in which Kuhne Shahr is situated we turned again into the mountains to cross on to the Turkish side.

On 31st August we arrived at the small Ḳurdish village of Ushnak and that afternoon while out shooting were attacked by a party of armed Kurds resulting in Mr. Hubbard being severely wounded. Arresting the guilty parties and to give Mr. Hubbard's wound time to heal necessitated several days' halt; Captain Wilson rejoined and moved down to Khōī with Captain Pierpoint in charge of Mr. Hubbard, who then had to be invalided to England. The Commissions moved on to Kotour, where we arrived on the 6th September, *en route* obtaining our first view of Mount Ararat, a vision which spurred every one to push on with the work, the end of which was thus in sight.

The delimitation of Kotour, where the frontier line has to cross a valley, forms a history by itself, many attempts have been made all resulting in failure, and once more we had to acknowledge defeat, and leave it undemarcated, a length of 40 miles in a frontier of over 1,100 miles forming the only portion of the delimitation which had to be left incomplete. On 9th September the Turkish Commissioner announced that he had received orders to cease work, and we all set to work to complete maps, description of the frontier, etc. These being completed up to Kotour, our Turkish colleague announced that he had received orders to omit Kotour and continue work to the north. This being agreed to we left Kotour on 18th September, not before having made a complete map of the district for future use, and crossed over on to the Turkish side. On 22nd September Major Cowie, Captain Brooke and the escort left to join Captain Wilson at Khōī, from whence they left for India. The two former officers with Captain Dyer proceeded *via* Julfā to Batoum where they caught up Captain Pierpoint and Mr. Hubbard and although the Dardanelles were closed they were able to reach Constantinople by sea, and thence by rail to Dedeagatch and by steamer to Port Said. The escort under Jemadar Tiwakli, with Surveyor Sijawal Khan and *khalāsis*, marching *via* Kirmānshāh and Isfahān, reached Muhammareh in January 1915.

The Commissions continued up the Turkish side demarcating the frontier as far as Kazli-queul, on the Persian side, which was reached on 27th September 1914. A halt here was necessary for a rather intricate piece of demarcation, but a severe snowstorm on 2nd October drove the Turkish Commission into Bayezid, while the remainder moved down to Kalissa Kandi and thence on 6th October to Bazirgan where Captain Wilson rejoined us. This was our last camp and one which we were not sorry to say good-bye to. The Turkish Commissioner never rejoined from Bayezid and his place after some delay was taken by his Deputy; however three weeks of patience and we were able to complete the work across the last valley and up the lava slopes of Mount Ararat to the neck joining it to Little Ararat and were able to have a final séance on 28th October and march into Makū that evening. A week previously Mr. Sher Jang and Hamid Gul had left with our few remaining men to march *via* Tabrīz to the Persian Gulf. Captain Wilson and Lieutenant-Colonel Ryder drove on 29th October in pouring rain into Shāh Takhti, 35

Persian Kurds (Ismail Agha's escort).

From a photograph by Major H. M. Cowie, R.E.

Persian Kurds (Ismail Agha's escort).

From a photograph by Major H. M. Cowie, R.E.

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1916.

TURCO-PERSIAN BOUNDARY COMMISSION, 1914.

Great and Little Ararat from the South.

From a photograph by Lieut.-Col. C. H. D. Ryder, C.I.E., D.S.O., R.E.

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1916.

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miles, the nearest railway station on the Julfā line; here next morning we heard of the Turks having bombarded the Black Sea ports, and realising that this meant their joining in the war, and closing the Constantinople route, we sent our servants with Mr. Abdul Alim to catch up Mr. Sher Jang's party, who got through to Būshire towards the end of January 1915 and travelling ourselves under the good auspices of Captain Tshahakaya reached Tiflis on 1st November 1914. Staying there only a few hours we left the same night after a reception of great warmth from the crowd at the station, and reached Baku on 2nd. We then decided that it was inadvisable to travel across Persia by ourselves, and that it would be best to go to Petrograd, so staying one night at Baku to avail ourselves of the company of Mr. Wilton, the King's messenger travelling from Tehrān to Petrograd, we left on 3rd and reached Petrograd on 6th November. We were then advised to take the Archangel route and leaving the same night, arrived there on 8th November, and after a delay of several days finally got started, broke our way through the ice in the river, and got out to the open sea.

Our route lay well into the Arctic Circle, passing the North Cape, latitude 70°, then hugging the Norwegian coast and steaming down the Fjords through magnificent scenery, but great cold, the whole country then being under snow, we were fortunate enough to see the Aurora Borealis on two nights, and reached England without incident on 21st November.

As regards the technical work of the Commission, the greater part was undertaken by the British up to latitude 36° and the Russians after that point, the Survey officers of the Turkish and Persian Commissions not having the necessary experience, but I should add that they worked cordially with us and accepted our surveys without hesitation, a fact in great part due to the confidence inspired by our Indian surveyors, all Mahomedans.

As it would have been impossible for any system of rigorous triangulation to keep pace with the work of the Commission, the system adopted for the triangulation was as follows:—

As the starting point Nasiri (Ahwāz) which had been connected in longitude, as already described, with Būshire, observations were taken for latitude and azimuth, and a base was measured with an Invar tape. With these data Major Cowie carried on a regular series of triangles as far as Umm Chir. From there to the Tyb river trigonometrical connection was maintained, partly by a regular series of triangles, partly by a short length of theodolite traverse. From the Tyb river onwards the regular series of triangles was discontinued and the following methods employed: from the advanced stations of the regular series two or more points in the directions in which we were moving were fixed by observations; when the Commission had marched to a suitable place in advance of these fixed points a base was measured, latitude and azimuth determined astronomically and a small network of triangulation carried out; from stations of the network observations were made to points fixed in rear permitting of the determination of the longitude of the network and at the same time further advanced points were fixed and used as described above when the Commission had in due course marched beyond them. This process was repeated as often as necessary, the last occasion being at Urūmieh, after which the Russians assumed responsibility for further work as they had already fixed many points by graphic triangulation on their large plane-tables. The results of the triangulation will be published on two sheets.

It had been laid down in the protocol of 14th November 1913 that the Identic Map was to serve as a base for the topographical work, but it soon proved insufficiently accurate for purposes of frontier demarcation. It was however decided to adopt the scale of this map 1 inch=1 geographical mile, or $\frac{1}{73,030}$ for our surveys, and this scale was retained with one exception for all maps up to latitude 36° when the Russian scale 1 inch=2 versts ($\frac{1}{84,000}$) was adopted as they had already printed maps on this scale of the Persian side of the frontier.

The exception above named was for " Carte Supplementaire No. 7 " where the scale of 1 inch=4 English miles had to be adopted owing principally to the lack of water.

The Identic Map was accepted for :—

(1) The Shatt-al-'Arab.

(2) The desert and march thence to Umm Chir.

(3) Between the Tyb river and near Baksai where the frontier simply followed the foot of the hill.

(4) The Shīrwān river.

(5) The Avromān range.

(6) The Kialou (Lesser Zāb) river.

It will be noticed that these comprise in most part in each case a single topographical feature which itself formed the frontier and of which an accurate map was not a necessity. The system adopted for carrying out the work did not vary greatly ; while we were responsible for the survey one or two surveyors supplied with topographical points by Major Cowie were sent on ahead and had their map ready by the time the Commission arrived.

From latitude 36° the Russian 2 versts map was completed by surveys on the Turkish side, and made use of, while our surveyors were employed making larger scale surveys of those areas which were under dispute, that is, of those places where the frontier left the watershed.

The country traversed was throughout, except between Mandalī and Qasr-i-Shīrīn, of an easy nature for surveying, especially in the absolutely treeless region in the north ; the difficulties we had to contend with were :—

(1) The want of water in the south and the great heat which resulted in haze and an abnormal amount of refraction.

(2) The tension in the north owing to the war and the general lawlessness amongst the tribes, Arab, Persian and Kurdish, along the whole frontier.

(3) The rapidity with which the Commission worked necessitated very rapid work on the part of the surveyors which again encouraged the Commission to work fast.

The British Survey detachment surveyed 7,500 square miles on various scales.

The length of the frontier from Fāo to Mount Ararat is 1,180 miles, of which 1,140 miles were demarcated, 227 pillars being erected, leaving only 40 miles undemarcated near Kotour.

In addition to the field work fair maps showing the frontier line have had to be drawn and were approved and signed by the Commissioners, 25 of such maps entitled " Cartes Supplementaires " were required as well as 10 " Cartes Detaillees " on larger scales to show difficult portions of the frontier.

Each nation had two manuscript copies of each of these 35 maps. The publication of the sheets 1 to 8 was undertaken by the Survey of India, Calcutta, the rapid and excellent printing of which enabled copies to be distributed before the close of the Commission; the remaining sheets were reproduced 6 to 15 by the War Office, London, and the remainder by the Survey of India.

The frontier line was also drawn in as accurately as possible taking into account inaccuracies on the map on 10 photographic copies of the Identic Map and on many copies of the reduced Identic Map.

I cannot close this report without referring once more to the energy, tact and skill displayed by the Survey detachment, Major Cowie, Mr. Sher Jang, K.B., and Surveyor Hamid Gul being worthy of special mention.

The sympathetic courtesy of Mr. Wratislaw, the energy of Captain Wilson and the tactful friendly demeanour of M. Minorsky, Aziz Bey, Etela-ol-Mulk and the members of the various Commissions contributed in no small degree to the success of the Commission.

All the officers of the British Commission were at various times willing victims to our demands for assistance in measuring bases and recording observations, while M. Minorsky who was accompanied throughout by his charming and energetic wife assisted us greatly by checking the spelling of names.

Of our technical colleagues, especially Captain Tshahakaya, the Persian Sartip Abdur Rezagh Khan and Lieutenant Kadri Effendi who all three accompanied the Commission from start to finish, I retain the warmest remembrance of their tact and friendliness often under difficult circumstances.

NEPĀL-PĪLĪBHĪT BOUNDARY SETTLEMENT.

BY MAJOR E. A. TANDY, R.E.

1. A reference to pages 93 to 97 of Records of the Survey of India, Volume V, will show the commencement of this work, which involved the alignment of straight links in place of the curved boundaries along the old course of the Sārdā river. As will be seen in the above report the straight links laid out for the Nainī Tāl portion of the Nepāl boundary, *i.e.*, up to old Reference pillar No. 27 (new Boundary pillar 17), were accepted by the Governments concerned; but the proposals concerning the Pīlībhīt portion (east of old Reference pillar No. 27) were not accepted by the Nepāl Durbar.

2. It was therefore decided to hold a fresh Boundary Commission to reconsider this portion during the winter of 1914-15.

Of this Pīlībhīt boundary there were only two portions falling on or quite near to the Sārdā river, namely, between old Reference pillar No. 27 and old Boundary pillar No. 19, and further east between old pillars Nos. 15 and 12. The interval, between pillars 19 and 15, lay on higher ground and therefore was not included in the preliminary work.

3. *Preliminary work.*—A small detachment, consisting of Mr. S. C. Mukharji, Sub-Assistant Superintendent, together with one traverser and one computer, was sent out in December 1914 to traverse over the two river sections mentioned above, and to correct the topography of the special 2-inch boundary maps of the previous year in respect of the latest movements of the river in the immediate vicinity of the boundaries. The jungle was cleared and the new traverses were run, not only along the old curved boundary, but also along possible alternative alignments.

This work was finished in January 1915, when the results were brought back to Dehra Dūn for final plotting and fair drawing, and arrangements were made for the Boundary Commission to meet on the ground.

4. *The settlement.*—Major E. A. Tandy, R.E., with the above detachment met the Commission noted in the margin, together with Lieutenant-Colonel J. Manners-Smith, V.C., C.V.O., C.I.E., Resident in Nepāl, on the 15th February 1915. With the assistance of the maps previously prepared it did not take long to examine all the possibilities on the ground, and a *Rubkar* was drawn up on the 21st February recommending the following settlement:—

Mr. G. Adams, I.C.S., Magistrate and Collector, Pīlibhīt.

Khan Bahadur Mangal Khan, Zemindar, Sherpur.

Lieutenant Chandra Shekhar Upadhya, Hakim of the Amini Kacheri, Kailali-Kanchanpur.

Lieutenant Basudeva Sharma Upadhya, Officer in charge of the Nepālese State Forests, Nayā Mulk.

(*a*) Starting from pillar No. 211 (the trijunction of Nepāl with the Kherī and Pīlibhīt districts) it was agreed that the eastern portion of the Nepāl-Pīlibhīt boundary as far as pillar No. 12, being on well-defined and high ground, required no alteration.

(*b*) From pillar No. 12 the boundary was to be aligned to a point distant about 17 to 18 chains to the W. S. W., where a new pillar was to be erected. From here the boundary was to run in a straight line to a similar point about 6 to 7 chains S. W. by S. of pillar No. 15, where also a new pillar was to be built. The remaining straight lines were to be :—from this point to pillar No. 19; from 19 to 21; from 21 to a point S. of Bandar Bojh Gauri so located that the total loss of area to Nepāl was not to exceed 200 acres; and finally from this point to pillar No. 17 of the Nainī Tāl-Nepāl series.

(*c*) It was further agreed that the numbering of the pillars was to be changed in continuation of the Nainī Tāl-Nepāl series, throughout the Pīlibhīt district up to its eastern limit (old pillar No. 211).

(*d*) A clearing of 60 feet throughout the boundary was to be kept as a neutral strip.

(*e*) After this boundary had been traced on the ground the Survey Department was to supply 2 copies of the map to each side, one copy of which was to be signed by the representative of each Government and given to the other in token of their acceptance.

5. *Final alignment.*—Mr. S. C. Mukharji, with his detachment, was then left to lay out the new boundary in accordance with the above agreement, and to fix it by traverse.

The boundary was laid out by plane-table on the scale of 16 inches to 1 mile, every peg being subsequently fixed by traverse. The field work was completed by the end of March.

6. *Demarcation.*—Along the whole line a clearing of 3 or 4 yards width was carried through the jungle and wooden pegs were put in at every furlong. These were of the nature of large tent-pegs and their site was further marked by 4 small "pointer" trenches about 1 foot deep. No demarcation of any kind was made across the areas covered with river sand and water, where marks would be washed away at once and the land is of no value.

7. *New pillars.*—The proposed sites for new pillars were marked by large wooden stakes, about 6 or 8 inches in diameter, and standing 6 feet to 20 feet above ground. They were surrounded by a circular 2-foot trench, the spoil

from which was formed into an earthen pillar round the stake. From this circular trench "pointer" trenches were dug as in the case of pegs but somewhat larger.

The sites were so selected that the materials from the existing pillars might be utilized with the least possible expense. Three old pillars, *viz.*, 12, 19 and 21, have been included in the series, and the only thing they need is the change of numbers.

8. The total loss to Nepāl was just under 200 acres. This balance against Nepāl was agreed to owing to the large excess of water and sand included in the areas they concede in straightening the boundary between old pillars 15 and 12; and also in consideration of concessions received by them in other districts.

9. The new boundary has been entered on the 2-inch boundary maps prepared the year before, and has been duly accepted by the Government of India and the Nepāl Durbar; but the final demarcation of the line by pucca pillars and the renumbering of the old pillars have been postponed till after the rains of 1915. The Survey of India has no responsibility in reference to this permanent demarcation, having supplied the local authorities with complete maps showing the line as temporarily laid out.

10. The traverse data have been stored in the office of the Trigonometrical Survey, Dehra Dūn. Sixty copies of the two new boundary maps were printed and most of them distributed to those concerned, the balance being stored with the Map Record and Issue Office, Calcutta.

Description of the new boundary between Nepāl and Pīlībhīt district, as settled in 1915.—(The alterations in the boundary have not yet been permanently marked by pucca pillars, but this is to be done next cold weather.)

The boundary runs *in straight lines* between the following pillars. Bearings are referrible to the origin of Survey, *viz.*, Sultānpur G. T. S.

Pillar No. 17.—Trijunction with Nainī Tāl district, *vide* Nepāl-Nainī Tāl Boundary description.

Boundary 17 to 18.—Distance 87·65 chains and bearing 146°-18′.

Pillar No. 18.—Is situated on the bank of a dry Nala 14 chains S. S. W. of Bandar Bojh Gauri.

Boundary 18 to 19.—Distance 25·44 chains and bearing 83°-25′.

Pillar No. 19.—Is situated in Chāndni Chauk on high ground about 8 chains E. of Sannia Nāla.

Boundary 19 to 20.—Distance 60·89 chains and bearing 83°-25′.

Pillar No. 20.—Is situated in Nojalha Naktha in thick forest of Jaman and Raini about 5 chains E. of Sannia Nāla.

Boundary 20 to 21.—Distance 43·77 chains and bearing 83°-25′.

Pillar No. 21.—Is situated in Nojalha Naktha in an open forest.

Boundary 21 to 22.—Distance 81·05 chains and bearing 83°-25′.

Pillar No. 22.—Is situated on the S. E. corner of the island of Chāndni Chauk near the junction of Sannia Nāla with the river Sārdā (old B. p. 21).

Boundary 22 to 23.—Distance 78·72 chains and bearing 130°-23′.

Pillar No. 23.—Is situated in an island covered with grass and young shisham on the dry bed of the river Sārdā.

Boundary 23 to 24.—Distance 49·85 chains and bearing 130°-26′.

Pillar No. 24.—Is situated on the high bank of a dry Nāla about 29 chains N. N. E. of Andua Gauri, W. of track from Andua Gauri to Shukla (old B. p. 19).

Boundary 24 to 25.—Distance 44·28 chains and bearing 137°-19′.

Pillar No. 25.—Is situated on track from Andua Gauri to Setha-Khera.

Boundary 25 to 26.—Distance 100·00 chains and bearing 137°-21′.

Pillar No. 26.—Stands in heavy jungle about 3 chains N. of a dry Nāla.

Boundary 26 to 27.—Distance 88·40 chains and bearing 137°-21′.

Pillar No. 27.—Is situated on high ground in an open forest.

Boundary 27 to 28.—Distance 189·03 chains and bearing 124°-28′.

Pillar No. 28.—Stands at the edge of a shisham grove in a grass plain.

Boundary 28 to 29.—Distance 77·02 chains and bearing 124°-28′.

Pillar No. 29.—Stands on high bank of Bamhni Nāla at the edge of dense Khair jungle about 12 chains N. of Dobhānia Gauri.

Boundary 29 to 30.—Distance 17·36 chains and bearing 72°-46′.

Pillar No. 30.—Is situated on W. bank of a dry Nāla in a khair forest about 24 chains N. W. of Dobhānia Gauri (old B. p. 12).

From pillar 30 onwards.—The old boundary has remained unchanged, excepting that the pillars are to be renumbered as follows:—

No. 11 becomes 31.	No. 7 becomes 35.	No. 3 becomes 39.
No. 10 becomes 32.	No. 6 becomes 36.	No. 2 becomes 40.
No. 9 becomes 33.	No. 5 becomes 37.	No. 1 becomes 41.
No. 8 becomes 34.	No. 4 becomes 38.	

APPENDIX.

List of Survey of India Publications.

Appendix.

LIST OF PUBLICATIONS

OF THE

SURVEY OF INDIA.

CONTENTS.

A—HISTORY AND GENERAL REPORTS.

B—GEODETIC WORKS OF REFERENCE.

C—CATALOGUES AND INSTRUCTIONS.

D—MISCELLANEOUS PAPERS.

APPENDIX.

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C—CATALOGUES AND INSTRUCTIONS
D—MISCELLANEOUS PAPERS

Note.—Unless otherwise stated, the publications are obtainable from The Superintendent, Map Publication, 13, Wood Street, Calcutta.

A—HISTORY AND GENERAL REPORTS.

MEMOIRS.

1. A Memoir on the Indian Surveys. *By C. R. Markham* . *India Office*, London, 1871.
2. Ditto (second edition). *By C. R. Markham, C.B., F.R.S.* . . . . *India Office*, London, 1878.
3. Abstract of the Reports of the Surveys and of other Geographical Operations in India, 1869—78. *By C.R. Markham and C. E. D. Black* . . . . *India Office*, London. Published annually between 1871 and 1879.
4. A Memoir on the Indian Surveys, 1875—1890. *By C. E. D. Black* . . . . *India Office*, London 1891.

ANNUAL REPORTS.

Reports of the **Revenue Branch** . . 1851 to 1877.—(1857—1870 out of print).
Ditto **Topographical Branch** . 1861 to 1877.—(1862—1866 and 1872—1875 out of print).
Ditto **Trigonometrical Branch** . 1861 to 1878.—(1863—1867 and 1868-1869 out of print).

In 1878 the three branches were amalgamated, and from that date onwards annual reports in single volumes for the whole department, are available as follows :—

General Reports { from 1877—1900 (1877—80 out of print) *at Rs. 3 per volume.* from 1900—1915 (1902—04 and 1906—08 out of print) *at Rs. 2 per volume.*

From 1900 onwards the Report has been issued annually in the form of a condensed statement known as the "**General Report,**" supplemented by fuller reports, which were called "**Extracts from Narrative Reports**" up to 1909, and since then have been styled "**Records of the Survey of India.**" These fuller reports are available as follows :—

(*a*) "**Extracts**" **Volumes** *at Rs. 1-8 per volume.*

1900-01.—Recent Improvements in Photo-Zincography. G. T. Triangulation, Upper Burma. Latitude Operations. Experimental Base Measurement with Jäderin Apparatus. Magnetic Survey. Tidal and Levelling. Topography in Upper Burma. Calcutta, 1903. (Out of print.)

1901-02.—G. T. Triangulation, Upper Burma. Latitude Operations. Magnetic Survey. Tidal and Levelling. Topography in Upper Burma. Topography in Sind. Topography in the Punjab. Calcutta, 1904.

1902-03.—Principal Triangulation, Upper Burma. Topography, Upper Burma. Topography, Shan States. Survey of the Sāmbhar Lake. Latitude Operations. Tidal and Levelling. Magnetic Survey. Introduction of the Contract System of Payment in Traverse Surveys. Traversing with the Subtense Bar. Compilation and Reproduction of Thāna Maps. Calcutta, 1905.

1903-04.—Magnetic Survey. Pendulum. Tidal and Levelling. Astronomical Azimuths. Utilization of old Traverse Data for Modern Surveys in the United Provinces. Identification of Snow Peaks in Nepāl. Topographical Surveys in Sind. Notes on Town and Municipal Surveys. Notes on Riverain Surveys, Punjab. Calcutta, 1906.

1904-05.—Magnetic Survey. Pendulum Operations. Tidal and Levelling. Triangulation in Baluchistān. Survey Operations with the Somaliland Field Force. Calcutta, 1907.

1905-06.—Magnetic Survey. Pendulum Operations. Tidal and Levelling. Topography, Shan States. Calcutta, 1908.

1906-07.—Magnetic Survey. Pendulum Operations. Tidal and Levelling. Triangulation in Baluchistān. Astronomical Latitudes. Topography in Shan States. Calcutta, 1909.

1907-08.—Magnetic Survey. Tidal and Levelling. Astronomical Latitudes. Pendulum Operations. Topography, Shan States. Calcutta, 1910.

1908-09.—Magnetic Survey. Tidal and Levelling. Pendulum Operations. Triangulation. Calcutta, 1911.

ANNUAL REPORTS—(*continued*).

(*b*) "**Records of the Survey of India**" *at Rs. 4 per volume, except where otherwise stated.*

SPECIAL REPORTS.

1. *Report on the Mussoorie and Landour, Kumaun and Garhwāl, Ranikhet and Kosi Valley Surveys extended to Peshāwar and Khāgān Triangulation during 1869-70. *By Major T. G. Montgomerie, R.E.* (Out of print.)
2. *Account of the Survey Operations in connection with the Mission to Yārkand and Kashghar in 1873-74. *By Captain Henry Trotter, R.E.* Calcutta, 1875.
3. Report on the Trans-Himālayan Explorations during 1869. (Out of print.)
4. Report on the Trans-Himālayan Explorations during 1870. Dehra Dūn, 1871. *Price Re. 1.* (Out of print.)
5. Report on the Trans-Himālayan Explorations during 1878. Calcutta, 1880. (Out of print.)

"**Notes of the Survey of India**" are issued monthly.

B—GEODETIC WORKS OF REFERENCE.

(*Obtainable from the Superintendent of the Trigonometrical Survey, Dehra Dūn, U. P.*)

EVEREST'S GREAT ARC BOOKS.

1. An account of the Measurement of an Arc of the Meridian between the parallels of 18° 3′ and 24° 7′. *East India Company* . . . . *London*, 1830. (Out of print.)
2. An account of the Measurement of two Sections of the Meridional Arc of India, bounded by the parallels of 18° 3′ 15″—24° 7′ 11″—and 29° 30′ 48″. *East India Company* . . . London, 1847. (Out of print.)
3. Engravings to illustrate the above. London, 1847. (Out of print.)

G. T. S. VOLUMES—Describing the Operations of the Great Trigonometrical Survey. *Price Rs. 10-8 per volume, except where otherwise stated.*

Vol. I.—**Standards of Measure and Base-Lines,** also an Introductory Account of the early Operations of the Survey, during the period of 1800-1830 . . . . Dehra Dūn, 1870. (Out of print.)

II.—**A History and General Description of the Reduction** of the Principal Triangulation. Dehra Dūn, 1879. (Out of print.)

III.—**North-West Quadrilateral.**—The Principal Triangulation, the Base-Line Figures, the Karāchi Longitudinal, N. W. Himālaya, and the Great Indus Series . . Dehra Dūn, 1873. (Out of print.)

IV.—**North-West Quadrilateral.**—The Principal Triangulation, the Great Arc—Section 24°—30°, Rahūn, Gurhāgarh and Jogi-Tīla Meridional Series and the Sutlej Series . Dehra Dūn, 1876.

IVA.—**North-West Quadrilateral.**—The Principal Triangulation, the Jodhpore and the Eastern Sind Meridional Series with the Details of their Reduction and the Final Results . Dehra Dūn, 1886.

V.—**Pendulum Operations** of Captains J. P. Basevi and W. J. Heaviside, and their Reduction. Dehra Dūn and Calcutta, 1879.

VI.—**South-East Quadrilateral.**—The Principal Triangulation and Simultaneous Reduction of the following Series:—Great Arc—Section 18° to 24°, the East Coast, the Calcutta and the Bider Longitudinal, the Jabalpur and the Bilāspur Meridionals . . Dehra Dūn, 1880. (Out of print.)

VII.—**North-East Quadrilateral.**—General Description and Simultaneous Reduction. Also Details of the following five Series:—North-East Longitudinal, the Budhon Meridional, the Rangir Meridional, the Amua Meridional, and the Karāra Meridional . . . . Dehra Dūn, 1882.

VIII.—**North-East Quadrilateral.**—Details of the following eleven Series:—Gurwāni Meridional, Gora Meridional, Hurilāong Meridional, Chendwār Meridional, North Pārasnāth Meridional, North Malūncha Meridional, Calcutta Meridional, East Calcutta Longitudinal, Brahmaputra Meridional, Eastern Frontier—Section 23° to 26°, and Assam Longitudinal . . . . . Dehra Dūn, 1882.

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* For Departmental use only.

G. T. S. VOLUMES—(*continued*).

Vol. IX.—**Telegraphic Longitudes**—during the years 1875-77 and 1880-81 . . . Dehra Dūn, 1883.
X.—**Telegraphic Longitudes**—during the years 1881-82, 1882-83, and 1883-84 . Dehra Dūn, 1887.
XI.—**Astronomical Latitudes**—during the period 1805 to 1885 . . . . Dehra Dūn, 1890
XII.—**Southern Trigon**—General Description and Simultaneous Reduction. Also details of the following two Series :—Great Arc—Section 8° to 18°, and Bombay Longitudinal . . Dehra Dūn, 1890.
XIII.—**Southern Trigon**—Details of the following five Series :—South Konkan Coast, Mangalore Meridional, Madras Meridional and Coast, South-East Coast, and Madras Longitudinal . Dehra Dūn, 1890.
XIV.—**South-West Quadrilateral**—Details of Principal Triangulation and Simultaneous Reduction of its component Series . . . . Dehra Dūn, 1890.
XV.—**Telegraphic Longitudes**—from 1885 to 1892 and the Revised Results of Volumes IX and X; also the Simultaneous Reduction and Final Results of the whole Operations . Dehra Dūn, 1893.
XVI.—**Tidal Observations**—from 1873 to 1892, and the Methods of Reduction . . Dehra Dūn, 1901.
XVII.—**Telegraphic Longitudes**—during the years 1894-95-96. The Indo-European Arcs from Karāchi to Greenwich . . . . Dehra Dūn, 1901.
XVIII.—**Astronomical Latitudes**—(1885 to 1905) and the Deduced Values of Plumb-line Deflections. Dehra Dūn, 1906.
XIX.—**Levelling of Precision in India**—(1858 to 1909) . . . . . . Dehra Dūn, 1910.
XIXA.—**Bench-Marks** on the **Southern** Lines of Levelling . . . Dehra Dūn, 1910. *Price Rs. 5.*
XIXB.—**Bench-Marks** on the **Northern** Lines of Levelling . . . Dehra Dūn, 1910. *Price Rs. 5.*

SYNOPTICAL VOLUMES—Giving charts, descriptions of stations, and full synopses of co-ordinates and heights of all stations and points fixed by Principal and Secondary **Triangulation.***

Price Rs. 2 per volume unless otherwise stated.

Italic figures are in chronological order and refer to the Index Chart of the G. T. Survey.

North-West Quadrilateral.

Vol. I.—The Great Indus Series (*32*). Dehra Dūn, 1874.
II.—The Great Arc—Section 24° to 30° (*6*). Dehra Dūn, 1874.
III.—The Karāchi Longitudinal Series (*25*). Dehra Dūn, 1874.
IV.—The Gurhāgarh Meridional Series (*23*). Dehra Dūn, 1875.
V.—The Rahūn Meridional Series (*33*). Dehra Dūn, 1875.
VI.—The Jogi-Tīla Meridional Series (*37*) and the Sutlej Meridional Series (*45*). Dehra Dūn, 1875.
VII.—The N. W. Himālaya Series (*29*) and the Triangulation of Kashmir (*36*). Dehra Dūn, 1879.
VIIA.—The Jodhpore Meridional Series (*62*) and the Eastern Sind Meridional Series (*64*). Dehra Dūn, 1887.

South-East Quadrilateral.

Vol. VIII.—The Great Arc—Section 18° to 24° (*8*). Dehra Dūn 1878.
IX.—The Jabalpur Meridional Series (*53*). Dehra Dūn, 1878.
X.—The Bider Longitudinal Series (*43*). Dehra Dūn, 1880.
XI.—The Bilāspur Meridional Series (*58*). Dehra Dūn, 1880.
XII.—The Calcutta Longitudinal Series (*5*). Dehra Dūn, 1880.
XIII.—The East Coast Series (*24*). Dehra Dūn, 1880.
XIIIA.—The South Pārasnāth (*1*) and the South Malūncha Meridional Series (*17*). Dehra Dūn, 1885.

North-East Quadrilateral.

Vol. XIV.—The Budhon Meridional Series (*2*). Dehra Dūn, 1883.
XV.—The Rangir Meridional Series (*4*). Dehra Dūn, 1883.
XVI.—The Amua Meridional Series (*3*) and the Karāra Meridional Series (*12*). Dehra Dūn, 1883.
XVII.—The Gurwāni Meridional Series (*19*) and the Gora Meridional Series (*15*). Dehra Dūn, 1883.
XVIII.—The Hurilāong Meridional Series (*21*) and the Chendwār Meridional Series (*14*). Dehra Dūn, 1883.
XIX.—The North Pārasnāth (*27*) and the North Malūncha Meridional Series (*13*). Dehra Dūn, 1883.
XX.—The Calcutta Meridional (*16*) and the Brahmapūtra Meridional Series (*56*). Dehra Dūn, 1883.
XXI.—The East Calcutta Longitudinal (*48*) and the Eastern Frontier Series—(23° to 26°) (*44*). Dehra Dūn, 1883.
XXII.—The Assam Valley Triangulation, E. of Meridian 92° (*55*). Dehra Dūn, 1891. (Out of print.)
XXXV.—The North-East Longitudinal Series (*20*). Dehra Dūn, 1909. *Price Rs. 5.*

Southern Trigon.

Vol. XXIII.—The South Konkan Coast Series (*11*). Dehra Dūn, 1891.
XXIV.—The Mangalore Meridional Series (*49*). Dehra Dūn, 1891.
XXV.—The South-East Coast Series (*63*). Dehra Dūn, 1891.
XXVI.—The Bombay Longitudinal Series (*7*). Dehra Dūn, 1892.
XXVII.—The Madras Longitudinal Series (*54*). Dehra Dūn, 1893.
XXVIII.—The Madras Meridional and Coast Series (*46*). Dehra Dūn, 1892.
XXIX.—The Great Arc Meridional Series—Section 8° to 18° (*9*). Dehra Dūn, 1899.

* Special charts can be supplied of those series for which no Synoptical Volumes are available, *viz.* :—all Burma, Chittagong and Baluchistan triangulation, the Assam Longitudinal, the Sambalpur Meridional, and the Gilgit Series, with a few recent Secondary Series in Indian.

SYNOPTICAL VOLUMES—(*continued*).

South-West Quadrilateral.

Vol. XXX.—The Abu Meridional Series (*26*) and the Gujarāt Longitudinal Series (*29*). Dehra Dūn, 1892.
XXXI.—The Khānpisūra Meridional Series (*18*). Dehra Dūn, 1893.
XXXII.—The Singi Meridional Series (*10*). Dehra Dūn, 1893.
XXXIII.—The Cutch Coast Series (*35*). Dehra Dūn, 1893.
Addendum to the Cutch Coast Series, (*Indus delta*) (separate pamphlet). Dehra Dūn, 1902.
XXXIV.—The Kāthiāwār Meridional Series (*28*). Dehra Dūn, 1894.

TRIANGULATION PAMPHLETS, with charts, are now being issued for every square degree, giving the results of all minor triangulation, as well as that shown in Synoptical Volumes. *Price Re. 1 per pamphlet.* *Vide* page ix.

LEVELLING PAMPHLETS—Giving heights and descriptions of all **Bench-marks**, fixed by levelling of Precision in India and Burma. Each pamphlet embraces an area of 4°×4° and the numbering is the same as that of the corresponding sheets of the 1/M map of India. Each is illustrated by a map of the area. *Price Rs. 2 per pamphlet, except where otherwise stated.*

Pamphlet	No.	Latitude.	Longitude.	Published.	Pamphlet	Nos.	Latitude.	Longitude.	Published.
India	**35**	24°—28°	64°—68°	Dehra Dūn, 1911.	India	**57**	12°—16°	76°—80°	Dehra Dūn, 1912.
„	**38**	32°—36°	68°—72°	„ 1912.	„	**58**	8°—12°	76°—80°	„ 1914.
„	**39**	28°—32°	68°—72°	„ 1913.	„	**63**	24°—28°	80°—84°	„ 1911.
„	**40**	24°—28°	68°—72°	„ 1911.	„	**64**	20°—24°	80°—84°	„ 1912.
„	**41**	20°—24°	68°—72°	„ 1913.	„	**65**	16°—20°	80°—84°	„ 1913.
„	**43**	32°—36°	72°—76°	„ 1913.	„	**66**	12°—16°	80°—84°	„ 1912.
„	„	Addendum		„ 1915.	„	**72**	24°—28°	84°—88°	„ 1912.
„	**44**	28°—32°	72°—76°	„ 1912.	„	**73**	20°—24°	84°—88°	„ 1913.
„	**45**	24°—28°	72°—76°	„ 1911.	„	**74**	16°—20°	84°—88°	„ 1913.
„	**46**	20°—24°	72°—76°	„ 1912.	„	**78**	24°—28°	88°—92°	„ 1912.
„	**47**	16°—20°	72°—76°	„ 1912.	„	**79**	20°—24°	88°—92°	„ 1912.
„	„*	Addendum		„ 1915.	„	„	Addendum		(*at press.*)
„	**48**	12°—16°	72°—76°	„ 1912.	„	**83**	24°—28°	92°—96°	„ 1912.
„	**49***	8°—12°	72°—76°	„ 1911.	Burma	**84**	20°—24°	92°—96°	„ 1911.
„	**52***	32°—36°	76°—80°	„ 1912.	„	„	Addendum		„ 1914.
„	**53**	28°—32°	76°—80°	„ 1912.	„	**85**	16°—20°	92°—96°	„ 1913.
„	**54**	24°—28°	76°—80°	„ 1914.†	„	**92**	24°—28°	96°—100°	„ 1911.
„	**55**	20°—24°	76°—80°	„ 1912.	„	**93**	20°—24°	96°—100°	„ 1911.
„	**56**	16°—20°	76°—80°	„ 1912.	„	**94**	16°—20°	96°—100°	„ 1911.

* Price Re. 1. † 2nd Edition.

TIDE TABLES—

Since 1881 Tidal predictions based on the observations of the Survey of India have been published annually by the *India Office, London.* The tables give the time and height of high and low water for every day in the year at each port, and are published early in the previous year. Current tables are available for the following 40 ports :—

Western Ports—

Suez (Egypt)—Perim—Aden—Maskat—Būshire—Karāchi—Okha Point and Bet Harbour (Gulf of Cutch)—Porbandar—Port Albert Victor (Kāthiāwār)—Bhaunagar—Bombay (Apollo Bandar)—Bombay (Prince's Dock)—Mormugao (Goa)—Karwar—Beypore (near Calicut)—Cochin—Minicoy (Indian Ocean)—Tuticorin—Pāmban Pass (Island of Rāmeswaram).

Eastern Ports—

Galle (Ceylon)—Trincomalee (Ceylon)—Colombo (Ceylon)—Negapatam—Madras—Cocanāda—Vizagapatam—False-Point—Dublat (Saugor Island)—Diamond Harbour—Kidderpore (Calcutta)—Chittagong—Akyab—Diamond Island (Burma)—Bassein—Elephant Point (Burma)—Rangoon—Amherst—Moulmein—Mergui—Port Blair.

The Tide Tables are issued in the following forms :—

(i) **Combined Volume**—including all the above ports—*Price Rs. 4.*
(ii) **Part I and Part II**—including Western and Eastern ports respectively—*Each part Rs. 2.*
(iii) **Pamphlets**—giving separately the tables for individual ports or for small local groups of ports—*Prices varying from As. 8 to Rs. 1-8 per pamphlet.*

C—CATALOGUES AND INSTRUCTIONS.

DEPARTMENTAL ORDERS.

From 1878 to 1885 the Surveyor General's orders were all issued as "*Circular Orders.*" Since then they have been classified as follows :—

From 1885 to 1904 as
1.—**Government of India Orders** (called "*Circular Orders*" up to 1898).
2.—**Departmental Orders (Administrative).**
3.—**Departmental Orders (Professional).**

DEPARTMENTAL ORDERS—(*continued*).

In 1904 the various orders issued since 1878 were reclassified as follows :—

Number to date.

1.—**Government of India Orders.**— *664.*
2.—**Circular Orders (Administrative).**—*347.*
3.—**Circular Orders (Professional).**— *188.*
4.—**Departmental Orders** (appointments, promotions, transfers, etc.).

These are numbered serially and had reached the above numbers by December 1915. *Government of India Orders* and *Circular Orders* (*Administrative*) are bound up in volumes from time to time, as shown below, while *Circular Orders* (*Professional*) are gradually incorporated in the Survey Hand-books. Besides the above, temporary orders have been issued since 1910 in the form of "**Circular Memos.**" These either lapse or become incorporated in some more permanent form, and are therefore only numbered serially for each year. Bound volumes of orders are available as follows :—

1. Government of India Orders (Departmental) 1878-1903.—Calcutta, 1904.
   Ditto (ditto) 1904-1908.—Calcutta, 1909. (Out of print.)
   Ditto (ditto) 1909-1913.—Calcutta, 1915.
2. Circular Orders (Administrative) 1878-1903.—Calcutta, 1904.
   Ditto (ditto) 1904-1908.—Calcutta, 1909.
   Ditto (ditto) 1909-1913.—Calcutta, 1915.
3. Regulations on the subject of Language Examinations for Officers of the Survey of India. Calcutta, 1914.
4. Map Publication Orders 1908-1914 (*Superintendent, Map Publication's Orders*).—Calcutta, 1914.
5. Specimens of papers set at Examinations for the Provincial Service.—Dehra Dūn, 1903.—*Gratis.*

CATALOGUES AND LISTS.

1. **Catalogue of Maps** published by the Survey of India. Second edition. Calcutta, 1915. *Price Re. 1.*
   NOTE.—Lists are issued quarterly of new maps published during each quarter, and similar lists for each month appear in the monthly NOTES OF THE SURVEY OF INDIA.
2. **Catalogue of Maps** of the Bombay Presidency, Calcutta, 1913. *Price As. 4.*
3. **List of Survey of India publications** (published annually)—*Gratis.*
4. **Price List of Mathematical Instrument Office.** Calcutta, 1913.
5. Catalogue of Books in the Headquarters Library, Calcutta, 1901. (Out of print.)
6. Catalogue of Scientific Books and Subjects in the Library of the G. T. Office. Dehra Dūn, 1908. *Price Re. 1.*
7. Catalogue of Books in the Library of the Trigonometrical Survey Office. Dehra Dūn, 1911. *Price Re. 1.*
8. **Green Lists**—PART I.—List of Officers in the Survey (*half-yearly to dates 1st January and 1st July*)—Calcutta.
   PART II.—History of Services of Officers of the Survey of India (*annually to date 1st July*)—Calcutta.
9. **Blue Lists**—Ministerial and Subordinate Establishments of the Survey of India.
   PART I.—Headquarters and Dehra Dūn Offices (*published annually to date 1st April*)—Calcutta.
   PART II.—Circles and parties (*published annually to date 1st January*)—Calcutta.

TABLES AND STAR CHARTS.

1. **Auxiliary Tables**—to facilitate the calculations of the Survey of India. Fourth Edition, revised. Dehra Dūn, 1906. *Price Rs. 4 in cloth and calf, or Rs. 2 in paper and boards.*
2. Tables for Graticules of Maps. Extracts for the use of **Explorers**. Dehra Dūn, 1910. *Price As. 4.*
3. *Metric Weights and Measures and other Tables. (*Photo-Litho Office*). Calcutta, 1889. (Out of print.)
4. Logarithmic Sines and Cosines to 5 places of decimals. Dehra Dūn, 1886. *Price As. 4.*
5. Logarithmic Sines, Cosines, Tangents and Cotangents to 5 places of decimals. Dehra Dūn, 1915. *Price Re. 1.*
6. Common Logarithms to 5 places of decimals.
7. Table for determining Heights in Traversing. Dehra Dūn, 1898. *Price As. 8.*
8. Tables of distances in Chains and Links corresponding to a subtense of 20 feet. Dehra Dūn, 1889. *Price As. 4.*
9. * Ditto ditto 10 feet. Calcutta, 1915.
10. * Ditto ditto 8 feet. Ditto.
11. Star Charts for latitude 20° N. *By Colonel J. R. Hobday, I.S.C.* Calcutta, 1900. *Price Rs. 1-8.* (Out of print.)
12. Star Charts for latitude 30° N. *By Lt.-Col. Burrard, R.E., F.R.S.* Dehra Dūn, 1906. *Price Rs. 1-8.*
13. *Catalogue of 249 Stars for epoch Jan. 1, 1892, from observations by the Survey. Dehra Dūn, 1893.
14. *Rainfall from 1868 to 1903, measured at the G. T. Survey Office. Dehra Dūn.

OLD MANUALS.

1. A Manual of Surveying for India, detailing the mode of operations on the Revenue Surveys in Bengal and the North-Western Provinces. *Compiled by Captains R. Smyth and H. L. Thuillier.* Calcutta, 1851.
2. Ditto ditto ditto ditto. Second Edition. London, 1855.
3. A Manual of Surveying for India, detailing the mode of operations on the Trigonometrical, Topographical and Revenue Surveys of India. *Compiled by Colonel H. L. Thuillier, C.S.I., F.R.S., and Lieutenant-Colonel R. Smyth.* Third Edition, revised and enlarged. Calcutta, 1875. (Out of print.)
4. **Hand-book, Revenue Branch.** Calcutta, 1893. *Price Rs. 2-8.*

* For Departmental use only,

SURVEY OF INDIA HAND-BOOKS.

1. **Hand-book of General Instructions,** Fourth Edition. Calcutta, 1914. *Price Rs. 3.*
2. **Hand-book, Trigonometrical Branch,** Second Edition. Calcutta, 1902. *Price Rs. 3.*
3. **Hand-book, Topographical Branch,** Third Edition. Calcutta, 1905. *Price Rs. 3.* (Out of print.)

• The following chapters of a revised edition of **the Topo. Hand-book** are available for issue in pamphlet form :—

Chapter I.—Introductory.
" II.—Constitution and Organization of a Survey Party.
" III.—Triangulation and its Computation.
" IV.—Traversing and its Computation.
" V.—Plane-tabling.
" VI.—Fair Mapping.
" VII.—Trans-frontier Reconnaissance.
" IX.—Forest Surveys and Maps.
" X.—Reproduction of the Sheets of the one-inch Map.

4. **Photo-Litho. Office,** Notes on Organization, Methods and Processes. Calcutta, 1914.
5. **The Reproduction (for the guidance of other Departments),** of Maps, Plans, Photographs, Diagrams, and Line Illustrations. Calcutta, 1914. *Price Rs. 3.*

NOTES AND INSTRUCTIONS.

Drawing and Paper.

1. *Notes on the Drawing of New Standard Maps. *By Major W. M. Coldstream, R.E.* Calcutta, 1908.
2. *Notes on Printing Papers suitable for Maps, and on Whatman Drawing Paper. *By Major W. M. Coldstream, R.E.* Calcutta, 1911.

Printing and Field Litho. processes.

3. *Report on Rubber Offset Printing for Maps. *By Major W. M. Coldstream, R.E.* Calcutta, 1911.
4. *Notes on the "Vandyke" or Direct Zinc Printing Process, with details of Apparatus and Chemicals required for a small section. *Compiled in the Photo and Litho Office, Survey of India.* Calcutta, 1913.
5. *Report on the Working of the Light Field Litho Press (Experimental) in November and December 1910 with Appendices. *By Lieutenant A. A. Chase, R.E.* Calcutta, 1911.
   (1) Notes on some of the Methods of Reproduction suitable for the Field.
   (2) Suggested Equipment Tables for the Light Field Litho Press (Experimental).
6. *Report on a trial of the equipment of the 1st (Prince of Wales' Own) Sappers and Miners for reproducing maps in the field. *By Lieutenant A. A. Chase, R.E.* Calcutta, 1912.

Base Lines and Magnetic.

7. *Notes on the use of the Jäderin Base-line Apparatus. Dehra Dūn, 1904.
8. *Miscellaneous Papers relating to the Measurement of Geodetic Bases by Jäderin Invar Apparatus. Dehra Dūn, 1912.
9. *Instructions for taking Magnetic Observations. *By J. Eccles, M.A.* Dehra Dūn, 1896.

10. **Rectangular Co-ordinates.**—On a Simplification of the Computations relating to. *By J. Eccles, M.A.* Dehra Dūn, 1911.
11. **For Explorers.**—Notes on the Use of Thermometers, Barometers and Hypsometers with Tables for the Computation of Heights. *By J. de Graaff Hunter, M.A.* Dehra Dūn, 1911.

D—MISCELLANEOUS PAPERS.

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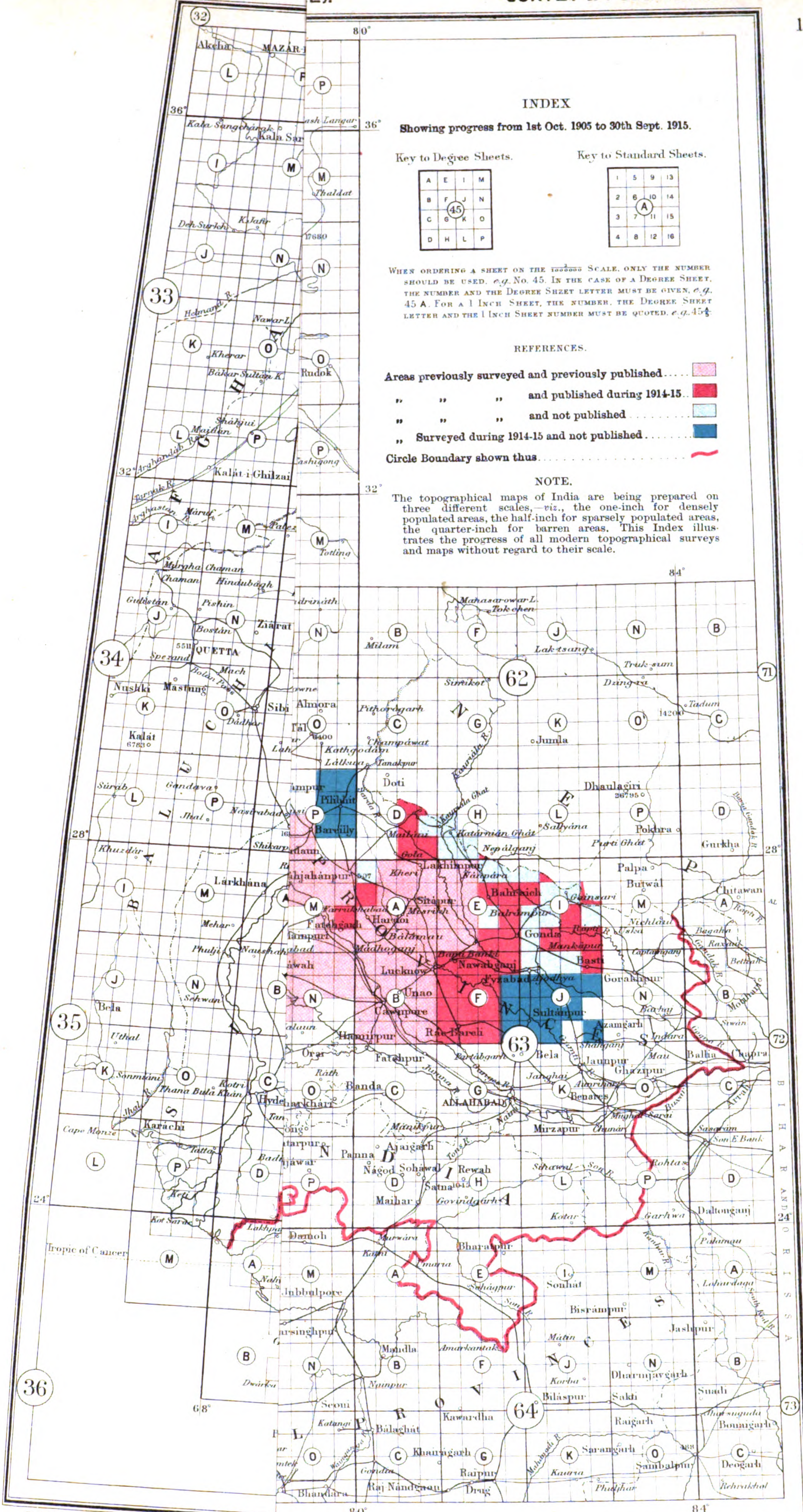

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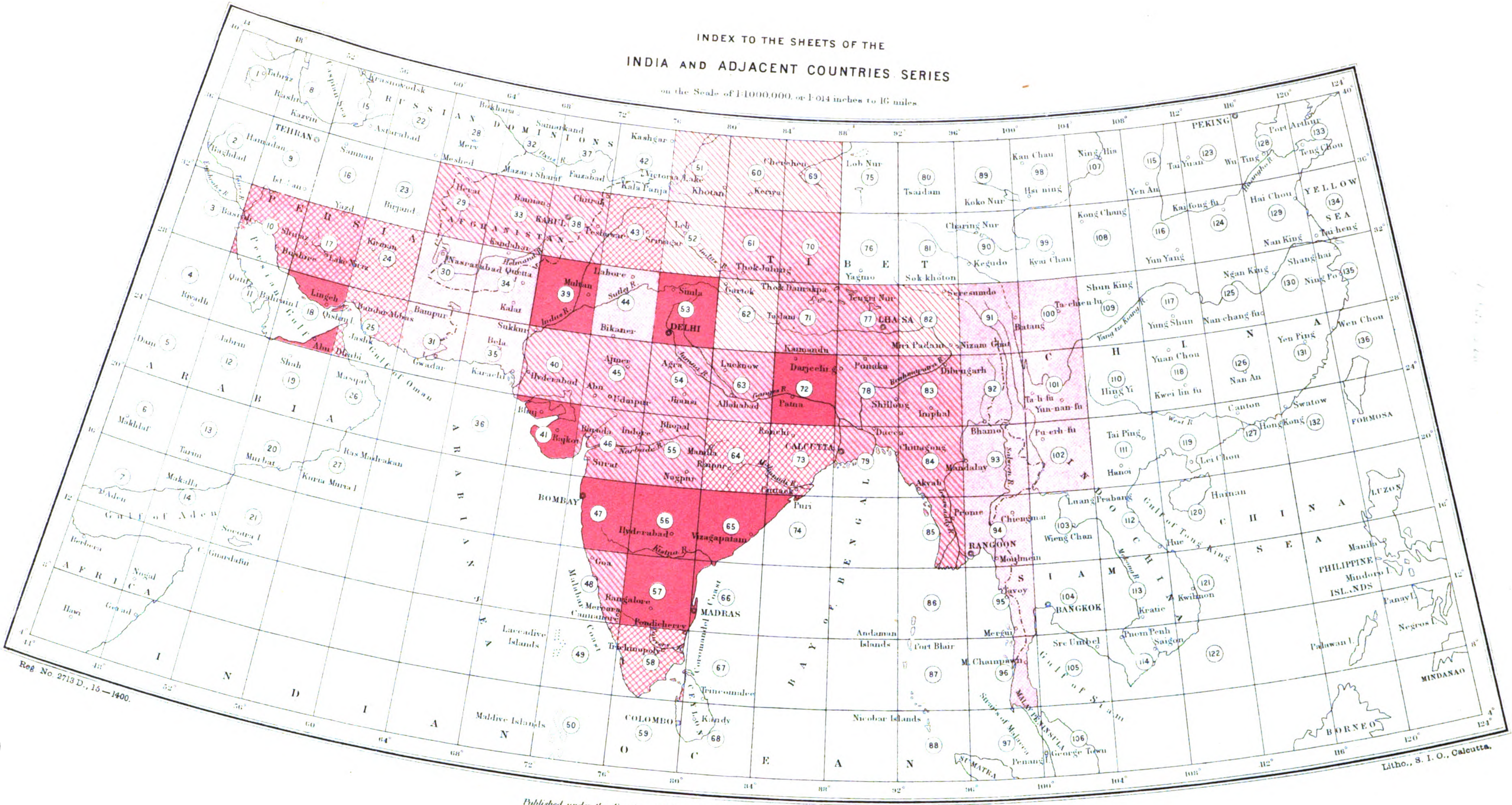

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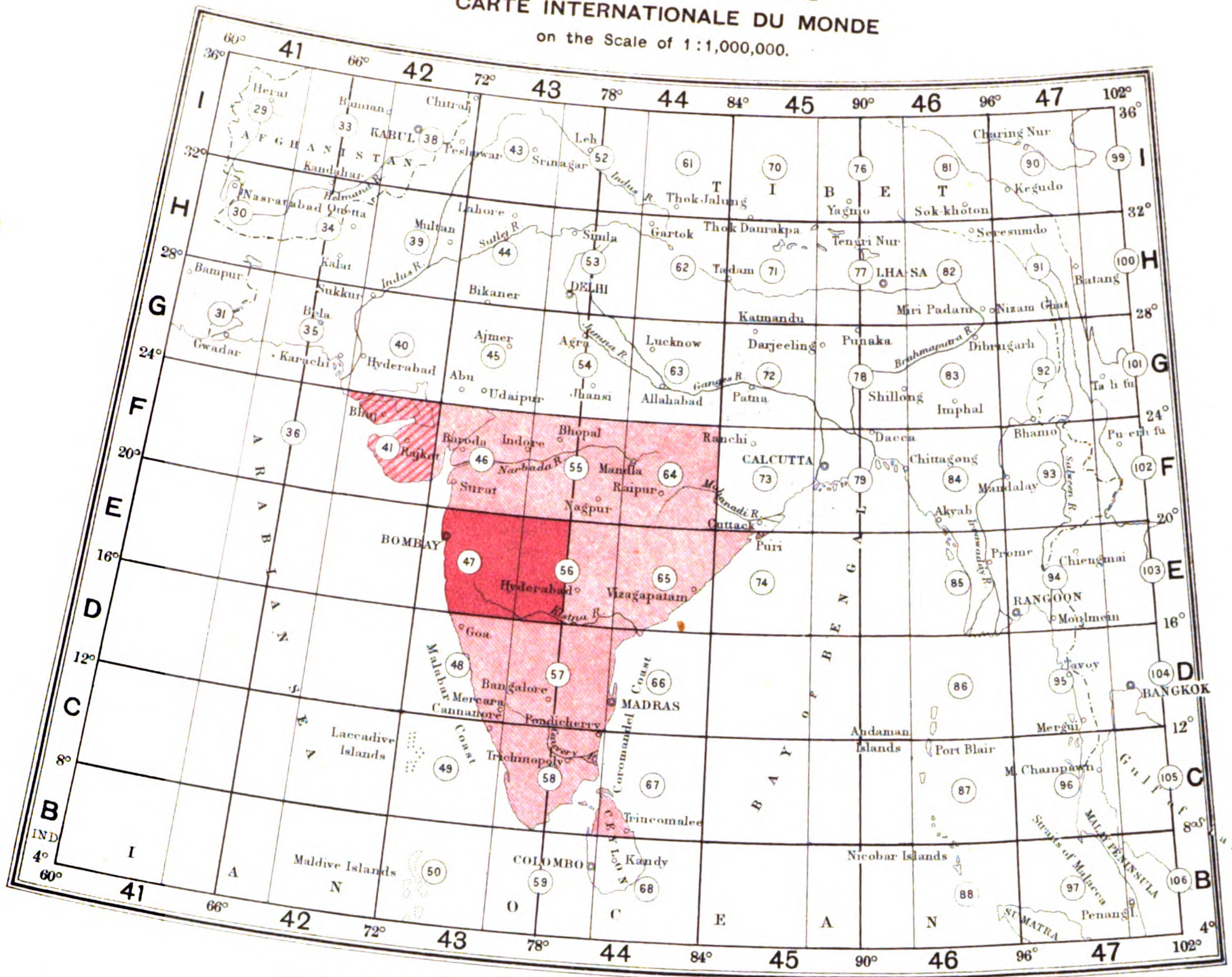

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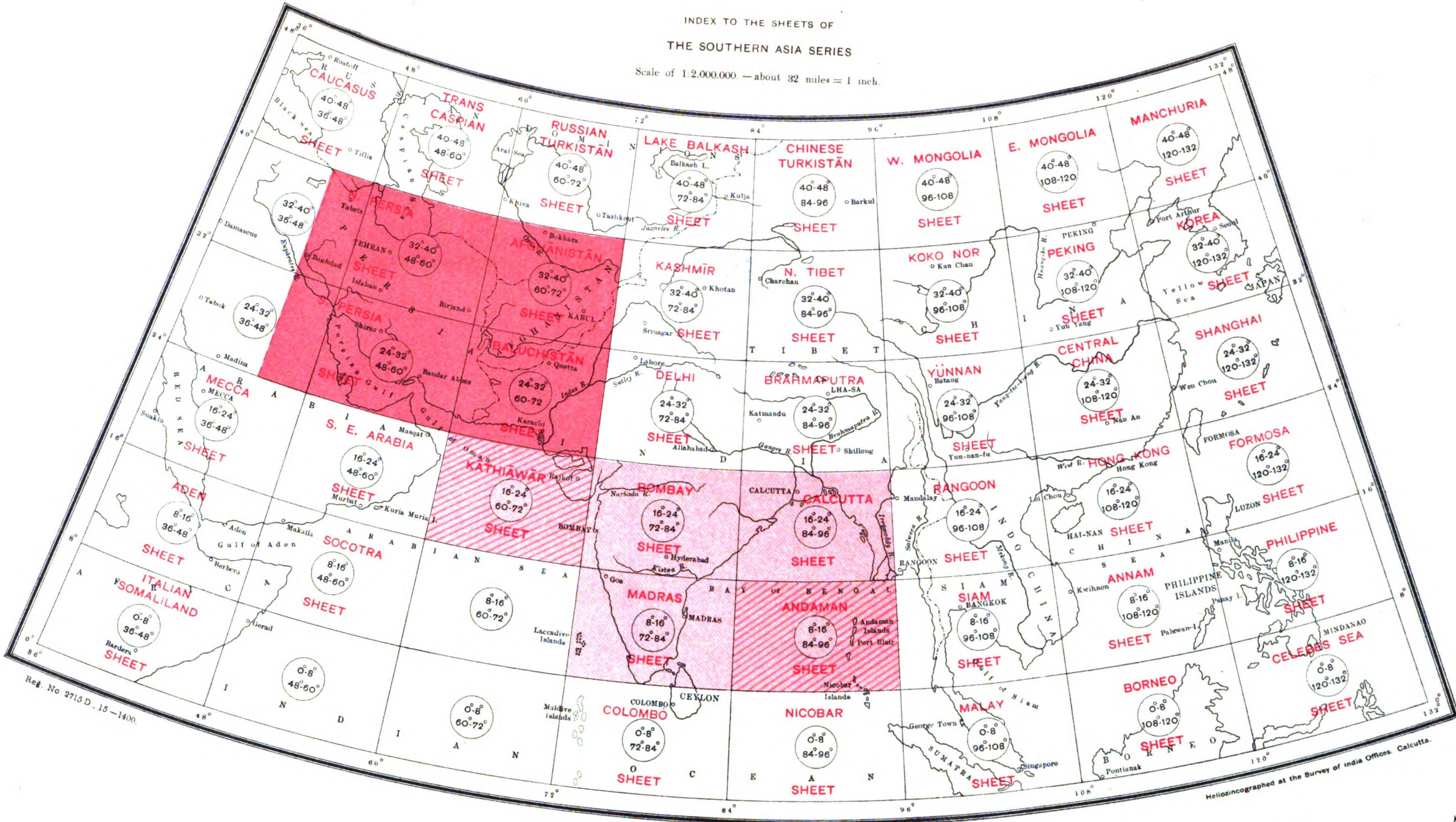

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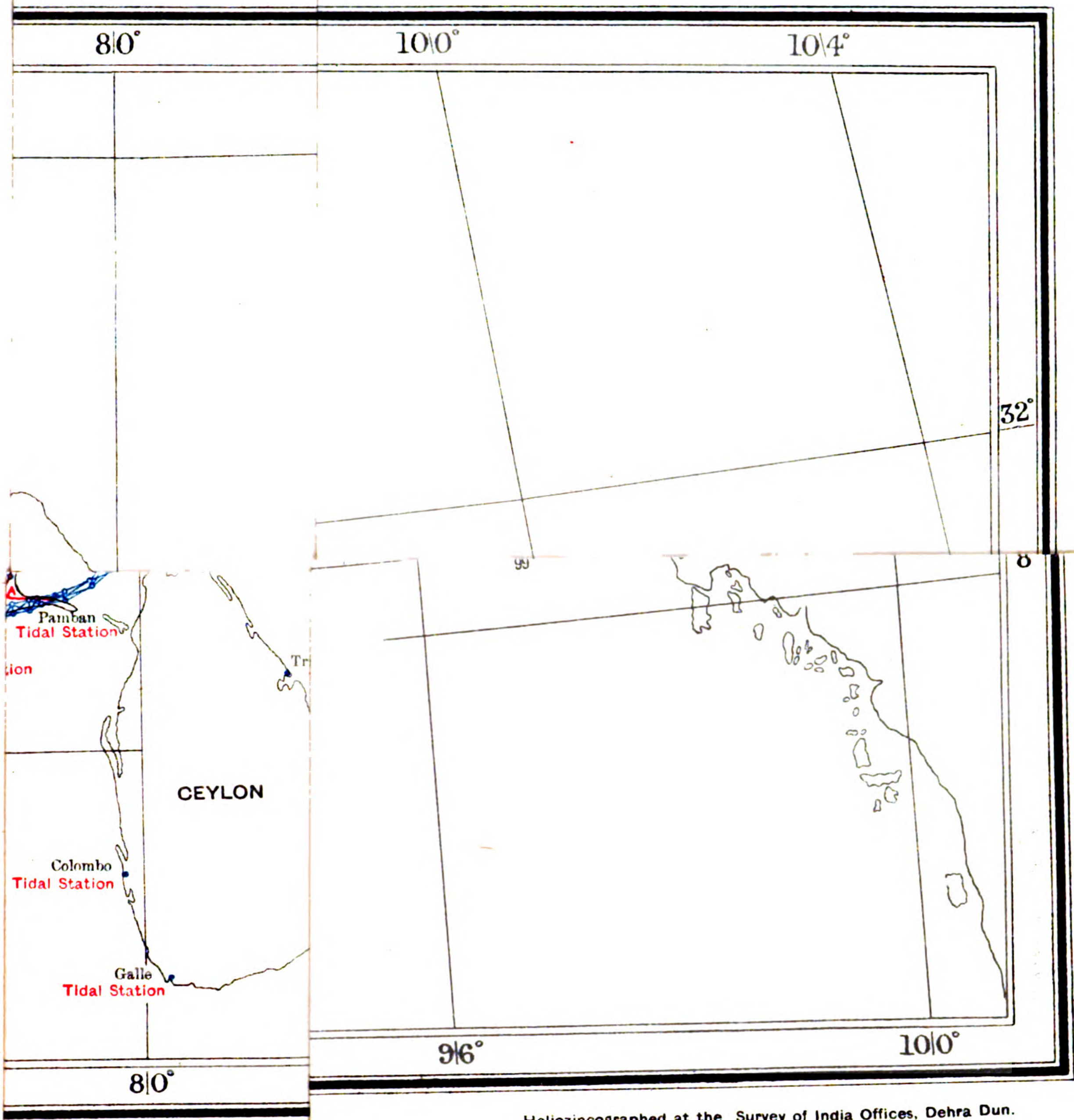

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